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Surface Coal Mining in the Northern Great Plains of the Western United States. An Introduction and Inventory Utilizing Aerial Photography Collected in 1974 and 1975

Environmental Protection Agency, Denver, Colorado

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SURFACE COAL MINING IN THE NORTHERN GREAT PLAINS OF THE WESTERN UNITED STATES

AN INTRODUCTION AND INVENTORY UTILIZING AERIAL PHOTOGRAPHY COLLECTED IN 1974-75

ENVIRONMENTAL PROTECTION
AGENCY
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REGION VIII

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SURFACE COAL MINING IN THE NORTHERN GREAT PLAINS OF THE WESTERN UNITED STATES

An Introduction and Inventory Utilizing Aerial Photography Collected in 1974 and 1975

June, 1976

Prepared by:

U.S. Environmental Protection Agency

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Assisted by:

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Las Vegas, Nevada
★States of North Dakota, Wyoming, and Montana★

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Billings, Montana
U.S. Department of Agriculture
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Billings, Montana

PREFACE

Approximately one half of the nation's coal resources, forty percent of the now economically recoverable uranium resources, and all of the present-day commercially feasible oil shale resources are contained within a six state area of the western sector. This six state area encompases the states of Colorado, Montana, North and South Dakota, Utah, and Wyoming. Also widespread in this area are present and future energy resources in the form of oil, gas, "tight gas", tar sands, geothermal, and hydropower developments. The existence of somewhat ideal conditions have led to experimentation in the utilization of wind and solar power within the area - another immense and virtually untapped resource. Major-scale energy initiations dependent upon these resources are presently occurring and proposed.

Other valuable resources play equally important roles within the six-state area. These resources include vast and fertile agricultural lands, extensive wildlife habitat and production areas, wild and scenic areas, national park areas, national forests, and abundant natural beauty. The area is not industrialized. Settlement has, however, been typically and greatly influenced by natural resource developments within the area such as mining.

In order to establish the environmental datum and management processes necessary for the orderly and sound development of the area's immense energy resources, the EPA has established a regional energy-environment program contained within the early stages of regional planning. This report is one of a series that provides the interested and concerned reader with a comprehensive understanding for the meaning of near-future extraction of western national coal resources. It is also hoped that this report will provide the proper introduction to a tool in the field of environmentally managed energy development - that of aerial color imagery. It is thought that this aerial color imagery will experience increased and widespread application.

We invite you to share with us your thoughts and experiences as you read and utilize this report. We also wish to express our sincere appreciation to all those public, industrial, and governmental entities which helped so willingly in providing information.

Cooper H. Wayman
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Office of Energy Activities

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ABSTRACT

Color aerial photography collected in 1974 and 1975 is presented to portray 21 surface coal mines and one surface uranium mine located in the Northern Great Plains Coal Province of Montana, North Dakota, and Wyoming. Geologic, hydrologic, engineering, operational, and other data are also presented. Through a brief description of surface coal mining operations, the uses of aerial photography, both color and color infrared, are introduced as tools for planning and regulating surface coal mining and secondary impacts thereof. A brief synopsis and example of a related effort involving satellite imagery is provided. The report provides a basis for planning and assessing surface mining of minerals in the interior western states.

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16. ABSTRACT

This report deals with the information portrayal of twenty-one surface coal mines and one surface uranium mine within the Northern Great Plains Coal Province of Montana, North Dakota and Wyoming. The aid of color aerial photography enables not only the diagrammatic layout of the mine to be presented, but also provides for the analysis, discussion, and conveyence of other interesting data. These other data include pertinent geologic, hydraulic, engineering, and operational information.

With the aid of a brief description of surface coal mining operational procedures, the uses of aerial photography, both color and infrared, are introduced to the readers as a tool for the environmentally oriented regulation and planning of surface coal mining facilities. Environmentally oriented regulation deals not only with the present physical disturbance of a natural area, but also with its sound management and eventual reclamation for further beneficial uses.

See attached sheet for continuation.--

17. KEY WORDS AND DOCUMENT ANALYSIS

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Coal	Surface Mining	Aerial Imagery	
Geologic Strata	Exploration	Satellite Imagery	
Remote Sensing	Spoil	Color Infrared	
Surface Ecosystem	Reclamation	Ranking Categories	
Revegetation	Photography	BTU	
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The close of this report includes a brief synopsis and example of related efforts involving the utilization of satellite imagery. A basis for the future planning, regulation and envirionmental assessment of surface mineral mining in the interior western states has been proposed within and by this report.

COLOR ILLUSTRATIONS REPRODUCED
IN BLACK AND WHITE

CHAPTER 1

INTRODUCTION AND BACKGROUND

This report is one of a series published dealing with coal mining by the Environmental Protection Agency. Previous reports have dealt with acid mine drainage most typical of many Eastern and Midwestern coal mines. More recently, the Agency has been involved in the full spectrum of pollution control activities surrounding energy development and has concentrated significant effort in assisting other Federal and State authorities in developing standards of performance that provide greater assurance that coal mining will be conducted in a manner that insures environmental protection. In so doing, the EPA believes it is important that the public understands the technology applicable to mining coal, the options and trade-offs available when planning and operating a coal mine, and the ramifications of preventing pollution from coal mines. This activity within the EPA involves responsibilities of the Office of Energy, Minerals, and Industry, Office of Research and Development and the Office of Energy Activities, Office of the Regional Administrator (Denver). It also involves responsibilities of water and enforcement-related programs.

Land disturbance caused by surface coal mining has potential for significant impacts in the form of sediments washed into streams of the affected watershed. As a result, sediment loads are increased. Exploration activities, haul and access roads, housing and service facilities all can disturb the land surface to a sufficient degree so as to increase sediment loads. Such activities can also expose sufficient soil and disturbed geologic strata and thereby create a larger potential for dust problems. Earth materials previously buried and compacted are broken and exposed to weathering. In the East and Midwest, lands disturbed by coal mining are exposed to high annual rainfalls which erode the lands and oxidize sulfur compounds contained in the coal beds. Where high concentrations of iron sulfide exist, these weathering processes may result in the creation of acid waters. Western coals are not generally associated with deposits of iron sulfides and acid drainage does not generally occur. High annual rainfall facilitates fast vegetative growth which in turn can stabilize the disturbed areas and hasten the formation of organic material in the surface materials. In the coal-rich plains and mountain foothills of the Western United States, average annual precipitation of six to twenty inches* somewhat reduces the total erosion and acid-forming potential from pyrites in coal, but makes it difficult for vegetation to grow. In an often confusing manner then, the precipitation-related reduction in erosion potential in the West is "compensated" for by the resulting sparseness of vegetative cover in terms of stabilizing soils, making the sediment problem as important in the West as the East.

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*Approximate average annual total (rain and snow) precipitation in areas in which coal is currently mined using surface mining methods. If on the order of 30% of the total annual precipitation is in the form of snow, much of this snow-moisture will be evaporated in the semi-arid climate as the result of sublimation. It is not, therefore, available to vegetation.

From this brief discussion, it easily follows that vegetation is important in mined land reclamation since successful establishment of vegetation on disturbed lands stabilizes those lands. Such stabilization reduces sediment yields in a manner that can require a minimum of caretaking by the mine operator after mining. That caretaking can involve maintenance of sediment catchment basins, reshaping the land surface, maintaining drainage diversion systems, mulching, and so on. It is equally apparent that pre-mining environmental assessment and comprehensive operation controls are key elements in assuring that coal mining in any region is environmentally acceptable.

Housing and service facilities for the mines, if improperly sited and constructed, can also cause water and air pollution. Transportation systems have high potentials for interfering with man's and wildlife activities. Thus, mechanisms such as aerial imagery that help to identify geologic and hydrologic hazards (e.g., landslides and floods), soils and vegetative systems, and hydrologic interrelationships facilitate the pre-activity planning and design necessary to mitigate and avoid these potential pollution problems.

This report addresses the tool of aerial imagery*, often included under the term of "remote sensing"**, principally as a mechanism to assist with planning and regulation of surface mining for coal. Aerial imagery provides a status report on numerous characteristics of mined land such as surface water hydrology, soil types, vegetative species and their condition, shallow ground water hydrology as it affects the surface ecosystem[+], physical modifications of the land surface caused by man, including changes in topography, and so on. This document, in presenting aerial imagery, provides a view of a spectrum of effects of surface coal mining, not the least of which is the visible effect on water quality. The characteristic responses of the aerial imagery presented are discussed in a later section. Ongoing research in this area is sponsored by the EPA at its Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

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*Aerial imagery refers to acquisition of information on film and is limited here to recording reflectance of electromagnetic radiation in the visible and near infrared ranges.

**Remote sensing is the acquisition of information by a recording device that is not in close proximity to the phenomenon under study.

[+] Surface ecosystem includes in this context principally the vegetative species dependent upon shallow ground water and the soil or rock at the surface. In the total sense, however, the phrase encompasses the terrestrial biological system which contains vegetation, soils, vertebrates, invertebrates, and thus includes man as he interacts with that system.

Aerial imagery is a useful means not only in the identification of reclamation activities in terms of topographic changes and viability of the vegetative ecosystem, but also in laying out a mining plan in a readily understandable format, with geologic data and up-to-date land surface information included in the imagery.

This report is also issued to relay selected information that various agencies have obtained over the past four years in the course of visits to surface coal mines. We feel strongly that it is necessary to describe reclamation activities in the same breath as one describes mining activities. It is both difficult and inappropriate to separate the planning for and operation of a coal mining operation from the reclamation of disturbed lands of a coal mine. For example, as a dragline removes rock laying over the coal, at which point does the dumping of that rock become reclamation? Further, surface mining of coal is viewed as a temporary imposition on other land uses. Therefore, reclamation of the land to a post-mining land use has to be an integral part of the mining plan. Lastly, the method of mining dictates the type and cost of reclamation (and vice-versa). Thus, this report presents data reflecting both mining and reclamation.

We have also found that the aerial imagery is invaluable when trying to assess the implications of proposed legislation or regulations on existing surface mining operations. It is equally useful in assessing the possible effects of planned operations.

Sometimes, it is equally rewarding to view the photography and just enjoy it. We invite you to use your imagination as well as your technical expertise as you proceed.

One last note of caution: most of the imagery presented was collected in 1974. A lesser amount was collected in mid-1975. Production of coal from the Northern Great Plains has increased significantly since then. Activities have changed. You should not, therefore, expect the imagery to accurately reflect current status of the mines. Nor should one expect the statistical information to accurately describe the current status. Larger areas have been mined and larger areas have been graded and seeded.

CHAPTER 2

COAL IN THE WESTERN UNITED STATES

The mines shown in this report lie within the Northern Great Plains Coal Province as that geographical area is defined by geologists. As such, the whole province includes all coal in Western North Dakota, coal occurring in the Missouri River drainage and East of the Rocky Mountains of Montana and Wyoming, coal in Western South Dakota, coal in the Denver Basin of Colorado and Raton Mesa of Colorado, and Eastern New Mexico. The information presented was derived from surface mines operating in the shallow coals of lignite and sub-bituminous rank occurring principally in Western North Dakota, Eastern Montana and Eastern Wyoming. Time has not permitted acquisition of equivalent information for Colorado, New Mexico, or Western Wyoming, but the aerial imagery methodology portrayed for the northern mines is equally applicable to surface mines in those areas as well as in Southern Utah and Arizona. The discussions center on the mining of coals that lie within about 60 meters (200 feet) of the land surface.

In excess of 1.5 trillion tons of coal are estimated to lie at all depths within this entire province. About 10 percent of this total amount is actually measured or at least strongly indicated by local measurements, and is also considered mineable; about 30 percent inferred (based on geologic studies), but not considered recoverable; and the remaining 60 percent only hypothesized (based on the statistical principles of geology and coal exploration). The 10 percent "actually measured or strongly indicated," or so-called "mineable reserve base," equals 160 billion tons and presently represents 37 percent (by weight) of the Nation's coal reserve base. Of this 160 billion tons, half is located within the Northern Great Plains such that mining by surface methods* is feasible. Assuming an 80 percent recovery during mining of this 80 billion tons, 64 billion tons of surface mineable coal might presently (1976) be considered "available" or as a "recoverable resource" using current mining and processing techniques, current economic criteria, and assuming that mining is permitted.

One must keep in mind that the estimated quantities of recoverable coal resources change as exploration and mining proceed. Over the last few years, the estimates of recoverable coal in the West have risen, primarily as the result of data obtained from increased exploration and more comprehensive analysis of existing information and to some undertermined degree as a result of rises in market prices for coal. However, there is still only a limited amount of information available to accurately estimate the quantity and quality of shallow western coals throughout the Northern Great Plains and the Rocky Mountain Coal Province.

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*The feasibility of surface mining is related to the thickness, quality and depth of a coal bed. Thin coal beds are economical to mine if they lie near the surface; the thicker the coal bed, the deeper the mine can be. Presently Northern Great Plains coals within 60 meters of the land surface, if thicker than about 2 meters, may be considered minable by surface mining techniques. A discussion of the standard classifications of coal resources is contained in Appendix I.

It is also noteworthy that the quantity of coal resource is nonetheless much more accurately estimated than is the quality. Coal of the Northern Great Plains, as it comes from the mines, differs in several aspects from many eastern coals.

- Sulfur content as percent by weight is often lower averaging perhaps 0.6 percent and ranging from 0.1 percent to 4.0 percent in the coals presently mined. Sulfur is organic and inorganic (pyrite, marcasite). The relative percentage of organic sulfur tends to be high in low sulfur coals.
- Ash content is moderate, ranging to almost 20 percent, but averaging 7 percent.
- Water content is high, ranging to almost 45 percent and averaging 30 percent.
- Heat content, on a run-of-mine basis, ranges from about 5,600 BTU per pound to 11,000 BTU per pound.

Table 1 provides some more detailed information, drawn from another report, on the content of various elements in these coals. These data are representative of coals presently mined and may not accurately reflect the nature of coals that may be mined in the future.

Their low heat and low fixed carbon content place most of these coals in the lignite and sub-bituminous ranking categories.* Since many of the coals in the rest of the Nation are of higher BTU values, in terms of heat content, the Northern Great Plains coal region does not contain quite as high a percentage of the Nation's coal in terms of heat value or energy as the tonnage figure of 37 percent previously noted

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*Principal coal rank classifications are lignite, sub-bituminous, bituminous and anthracite. Heat content and fixed carbon tend to increase from the lignites to the anthracites, while moisture content tends to decrease. Coal is also classified by grade, which is a function of its ash content, sulfur content, and content of other elements that affect use. DeCarlo, J.A., Sheridan, E.T., and Murphy, Z.E., (1966 "Sulfur Content of United States Coal": U.S. Bureau of Mines Information Circular 8312) indicate that sulfur content of bituminous coals is higher than for higher or lower rank coals.

TABLE I

COMPARISON OF THREE NORTHERN GREAT PLAINS COALS WITH OTHER U.S. COALS

Element	Coal I lb/10^9BTU	Coal I ppm Dry Weight	Coal II lb/10^9BTU	Coal II ppm Dry Weight	Coal III lb/10^9BTU	Coal III ppm Dry Weight	Average of (Illinois Basin) 82 Coals lb/10^9BTU	Average of (Illinois Basin) 82 Coals Dry Weight
Sulfur	760	0.72%	420	0.49%	1460	1.44%	2750	3.51%
Mercury	0.014	0.13	0.012	0.14	0.0075	0.074	0.016	0.21
Chlorine	4.6	44	0.80	9.4	5.6	55	120	0.15%
Antimony	0.056	0.53	0.014	0.16	0.041	0.40	0.11	1.35
Fluorine	15	140	5.7	67	5.8	57	4.7	59.3
Selenium	0.23	2.2	0.14	1.6	0.13	1.3	0.16	1.99
Lead	0.44	4.2	0.20	2.3	0.087	0.86	3.1	39.83
Molybdenum	0.42	4.0	0.055	0.64	0.20	2.0	0.62	7.96
Nickel	0.95	9.0	0.18	2.1	0.55	5.4	1.7	22.35
Boron	5.4	51	2.6	31	15	150	8.9	113.79
Zinc	2.5	24	0.35	4.1	0.79	7.8	25	313.04
Cadmium	0.019	0.18	<0.008	< 0.1	0.020	0.20	2.3	2.89
Chromium	2.2	21	0.79	9.3	1.3	13	1.1	14.10
Copper	3.6	34	2.6	31	1.1	10.5	1.1	14.09
Cobalt	0.22	2.1	0.13	1.5	0.076	0.75	7.2	9.15
Uranium	0.14	1.3	0.076	0.89	0.15	1.5		
Arsenic	0.087	0.83	0.21	2.5	0.81	8.0	1.2	14.9
Silver	0.0047	0.045	0.0041	0.048	0.0035	0.034		
Barium	14	130	39	460	45	440		
Beryllium	0.086	0.82	0.025	0.29	0.061	0.60	0.13	1.72
Vanadium	5.4	51	1.7	20	1.5	15	2.6	33.13
Aluminum	2420	2.3%	610	0.71%	750	0.74%	960	1.22%
Calcium	1850	1.76%	930	1.09%	1400	1.38%	580	0.74%
Iron	420	0.40%	180	0.21%	760	0.75%	1610	2.06%
Manganese	18	170	2.0	24	8.0	79	4.2	53.16
Magnesium	300	0.29%	130	0.15%	380	0.37%	39	0.05%
Titanium	120	1100	48	565	35	350	47	0.06%
BTU/lb(dry)	--	9511	--	11708	--	9838	--	12750
Ash (dry basis)	21700	20.6%	6150	7.2%	12600	12.4%	8850	11.28%
Moisture	38800	27.0%	35200	29.2%	59300	36.8%	8730	10.02%

suggests. If one adopted an average heat content for western coals of 9,000 BTU per pound, and an average of 12,000 BTU per pound for midwestern and eastern coals, the national coal energy reserve base, on a BTU basis, for the Northern Great Plains would be on the order of 30 percent. But then this does not reduce the demand for these western coals and the low heat content is often compensated for by a lower cost of mining the thick, shallow coals.

Coal was formed from thick and extensive accumulations of biological, principally vegetative, matter buried through geologic time. Development of the thick coal seams of the West required very large flooded areas (swamps) which slowly subsided while growth of vegetation was optimal.* The paleoenvironment often produced a cyclic sequence of sedimentary strata, ideally consisting of coal overlain by marine shale and limestone and underlain by a sequence consisting, in progressively deeper manner, clay, fresh water argillaceous strata and sandstone and shale.** Paleogeographic conditions for western coals have not been thoroughly described. In general, the deeper the coal was buried through geologic history, the higher its present-day heat content. Coals mined underground are often of higher rank or sufficient quality to be used for coke. The volatiles of the vegetative matter of coal are reduced by the increased pressures and temperatures of burial. The fixed carbon percentage increases commensurately. The higher rank coals tend to occur in thinner beds and in deformed attitudes (folded and faulted).

The lower rank coals of the Northern Great Plains often occur in horizontal to gently dipping beds. The Northern Great Plains coals, especially those beds shallow enough to be considered surface mineable, increase in rank from lignite to bituminous westward across the Province. In the Rocky Mountain Coal Province, adjoining the Northern Great Plains Province on the west, coal beds tend to have been folded as well as buried deeper. The coal beds in the western part of the Northern Great Plains Province are also generally thinner and a number of beds may occur in close proximity to each other. The number of beds is not, however, a function of coal rank, but rather of depositional conditions. "Multiple seam (bed) surface mining" is practiced in western Wyoming, Colorado, New Mexico, and Arizona where individual coal beds, sequentially mined, may be vertically separated by 10 meters (33 feet) or more.

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*See "Final Environmental Impact Statement - Proposed Federal Coal Leasing" pages I-32 through I-39 for a concise, useful description.

**The sequence lacks a limestone in western coals thereby leading to questions as to the depositional environments that facilitated formation of these western coals.

In one western location, seven individual coal beds may be sequentially mined.

Measured coal bed thicknesses have been reported to range up to 60 meters (200 feet) in the Northern Great Plains. However, it is likely that any such "beds" contain partings* and therefore consist of a number of coal beds, closely spaced in a stratigraphical or vertical sense. The thickest coal bed mined presently is the Anderson Canyon ("Wyodak") seam mined immedaitely east of Gillette, Wyoming, comprised of two twelve-meter thick (40 feet) coal beds with only a thin shaley parting in between for an aggregate thickness of twenty-four meters of coal.

It may be useful to note that coal beds may thin out and end, may split into more than one bed and then "regroup" into perhaps one bed again. Coal bed nomenclature can thus become complex and it is not surprising to find the same bed with different names and different beds with the same name. The degree of confusion is inversely proportional to the amount of exploration conducted.

Adding to the confusion is the extensive natural (in situ) burning of coals in Montana and Wyoming which results in loss of coal outcrops and, possibly, subsidence of overlying shales and siltstone. Lastly, the coals are more than occasionally faulted resulting in challenges to mapping and correlations. Such discontinuities are compounded by the divisions in land and mineral ownership and in leasing. Conversely, the extensive outcrops of burned coal (clinker) and baked clay and shale ("porcellanite") facilitate exploratory mapping of coal seams and appear to play an important role in the shallow ground water aquifer systems of Montana and Wyoming.

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*Parting usually refers to a bed of shaley strata occurring between two coals where the thickness of the shale is thinner than the coal. In the West, this material tends to be saline and toxic to certain vegetative species when present in thicknesses of more than a meter.

CHAPTER 3

COAL MINING METHODS IN THE WESTERN UNITED STATES

Surface coal mining methods are becoming better known as a result, perhaps, of renewed national interest in coal. Surface mining can be described as extraction of a mineral resource in a manner that first requires removal of all earth materials that overlie the desired mineral resource. The majority of coal mining in the Western United States is surface mining. However, in western Colorado and in Utah, and thus, in that portion of the Rocky Mountain Coal Province, underground mining prevails. Surface mining is currently a highly efficient method of producing coal from those vast coal deposits lying near the land surface. Underground mining of those same coals is inefficient and dangerous. However, our dependence upon underground mining will increase as the shallow coals are removed.

The first stage of coal mine development, after certain entry rights are acquired and whether subsequent extraction is by surface or underground methods, is exploration. Despite the advanced age of the science of geology and the high degree of knowledge of geologic mechanisms that create coal, it remains necessary to conduct drilling, perform chemical analysis, and implement other exploration procedures even prior to removing relatively shallow coals. Exploration efforts are directed toward determining the precise depths to coal, and locations, thickness and quality of coal. To plan a safe and economic mine, the operator needs to determine accurately the depth to coal and overburden characteristics (the latter, for example, to determine roof strength in the case of an underground mine and for blasting data in the case of the surface mine), the quality of coal (which affects the mining sequence), its thickness, and the rock conditions beneath the coal. Pre-mining determinations of overburden strength are critical both for underground mining and are essential for determining surface mining methods. Major overburden removal equipment may be determined by the hardness of the overburden. Detailed coal quality (BTU content, ash, sulfur, volatiles) varies both vertically and horizontally within a single bed and from bed to bed, so that mined coal may need to be blended to meet contract specifications. Coal may occur in lenses and thus disappear within a short horizontal distance. A coal bed's location, thickness and depth cannot be precisely predicted, and therefore, equipment specification dependent on these data may not be finalized until exploration data are sufficient to answer such questions. For example, it may be necessary to mine from

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*At present, large surface coal mines in the western United States have been located principally where an operator has first gained control of the surface overlying coal through lease, agreement, or purchase. Only then does there begin a detailed resource analysis.

a number of individual pits in order to meet contract specifications for coal quality and this may determine the size and the type of mining equipment required.

Exploration procedures include interpretation of aerial imagery and acquisition of geochemical and geophysical (seismic, electrical, magnetic) data. As noted earlier, the purpose of exploration is to define the resource and its surroundings to reduce the risk in developing the coal resource -- to reduce the unknowns. The information is used in planning the mining operation to meet applicable laws and regulations.

Exploration activities usually involve the use of drilling rigs, either truck or trailer mounted; in the region of western coals, such rigs are equivalent to small water well drilling outfits with capabilities to drill at least 80 meters (250 feet). Many drilling operations use air and minimal water for drilling. The greatest potential that exploration activities hold for adverse impact on the land lies in off-road travel. Truck and dozer trails are susceptible to erosion and to future unauthorized use unless the vegetative (biological) system is encouraged to return. In some isolated cases, improperly plugged drill holes may serve to allow water under artesian pressure to escape to the surface.

Exploratory drilling is being used to a greater extent to obtain data on the occurrence of subsurface water at the mine site and to subsequently determine the quality of overburden in terms of its reclamation potential. In these cases, water and soil samples are collected and analyzed to project the impact of surface mining and reclamation on water quality in terms of the leachability of overburden and the ability of the overburden to maintain vegetation. This activity has increased importance in surface mining of western coals because the shallow coals are usually portions of locally-significant aquifers.

Exploration activities are also carried on after a mine is in operation. This activity is principally "development drilling". In the case of underground mines, most extensive development drilling may be necessary prior to production. In the case of surface coal mines in the western United States, pre-mining exploration activities generally produce sufficient information to permit development of an accurate mining plan for ten or more years of mining. In the case of the Exxon Highland Uranium Mine located in eastern Wyoming and included in the aerial photography of this report, development drilling is most extensive druring mining and the surface result of close-spaced drilling shows clearly on the imagery.

The surface mining process is often initiated on a new lease area in the western United States by excavation of a relatively small pit from which a number of thousand tons of coal are extracted for a test burn at a use or conversion point, usually a power plant. Access and haul roads are then constructed for delivery of materials and later transport of coal. At the same time, a rail spur may be constructed if rail transport of coal is planned. Two or more large coal storage silos will often be constructed (or a pit and shed) to store and protect the coal. Also possible is the construction of a slurry pipeline and associated preparation, water supply and pumping facilities. An early use of a railroad spur is often for the delivery of a shovel and/or dragline. The dragline and other large equipment is then constructed on-site and takes on the order of a year to complete.

Using diesel-powered tractors, scrapers, or other conventional earth-moving equipment, the first major earth-moving activity at a surface mine is the removal of soil. For dragline operations, a relatively flat bench must be created upon which the dragline operates. This bench may not be a straight path, but will rather follow an area of equal thickness of overburden or follow a route dictated by haul routes, land ownership, quality of coal, or other factors. Certain surface mining operations may not be required to preserve the unconsolidated soil. In these instances, a dozer may be used to level vegetation and soil so that stripping equipment has access to the overburden, or the soils and vegetation may be moved as overburden using draglines. In locations where soil is saved or segregated for replacement, scrapers are employed. In select cases, front-end loaders or shovels and trucks are used. On occasion, a dragline or large shovel may be used to move soil separately.

This period is an extremely sensitive one in terms of erosion potential of the disturbed soil and overburden. This sensitivity is increased in areas of new mines where often the surface runoff diversions and retention facilities are inadequate to control higher flows or pricipitation events.

In most areas of the Northern Great Plains Coal Province, it is necessary to prevent large amounts of runoff from reaching the mine pit. Thus, diversion dams and ditches may be seen uphill from many of the mines. Sedimentation ponds and discharge points are visible. Dust is no stranger in western mining operations, even in these early stages of mining such as soil removal. Under certain conditions, it becomes possible to see, in aerial imagery, dust accumulations in patterns downwind of the mining and hauling operations. Control measures such as sprinkling are often visible in the aerial imagery. In some cases, perennial streams are diverted around the areas to be mined.
The increased probability of this stream diversion activity has created significant interest in obtaining a better understanding of stream

dynamics during and after such diversions.

If the overburden is hard (indurated), it will be blasted prior to removal using ammonium-nitrate and fuel oil packed in 8 to 30 centimeter diameter holes drilled on 3 to 6 meter centers. The drill hole pattern is often reflected in the aerial imagery. In mines such as the Belle Ayr South Mine of AMAX Coal Company, overburden has not been blasted, but has been removed directly by shovel and front-end loaders. Similar solutions exist for removal of the coal. But it appears "normal" to blast the overburden and coals prior to removal in the West. A bulk tank for ammonium-nitrate is located on the mine site in most cases.

Removal of the overburden is often achieved using equipment called a "dragline". The usual dragline is best described as "huge". Standing perhaps 20 meters tall and with a higher boom, they suggest a drawworks and maintenance shop, if not a house, on "wheels." Draglines operate by pulling (toward the operator or away from the operator) on a bucket in contrast to shovels which undercut by digging out away from the shovel drawworks and up. Both large shovels and draglines are used almost exclusively to handle overburden in the West. Draglines are generally characterized by the capacity of the bucket and the "throwing" radius within which the draglines can excavate and dump. This radius is dictated by the length of the boom that supports the bucket. The boom length must be scaled (inversely proportioned or otherwise strengthened proportionally) to bucket capacity. The boom length also determines the practical depth capabilities of the dragline. All of these dimensions are affected by the type of overburden encountered and, in turn, certain dimensions affect the method of overburden placement. More specifically, hard overburden may require a reduction in boom length. A longer boom may allow more selective placement of overburden material. The latter is an important consideration since it permits material conducive to plant growth to be segregated from potentially toxic spoils with a minimum of rehandling and/or hauling. Today's large draglines are "walking". The walking mechanism consists of a shaft, cam and elongated pontoon-like box commonly called a "shoe" which moves up and down. The shoe serves as the base for the cam-jacking arrangement. The dragline is supported by the cam-jack as it moves. The shoes are retracted

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*The material removed from above the coal beds in surface mining is often called overburden though it may include material that lies between two or more coal beds. As the overburden is removed and placed elsewhere, it is called "spoil" because the material is essentially useless to the coal recovery process.

while operating and the dragline rotates on a circular rail supported by a steel rim or tub.

An alternative method of overburden removal uses large shovels. Shovels must work from below the material excavated. The excavation procedure, as noted earlier, is "up and out." Shovels may be as large as draglines, but (1) generally require a hard coal since they may work off the top of the coal, (2) generally are designed to move material as far away from the pit as can a large dragline, and (3) are normally used in conjunction with trucks that haul away the materials. Of course, those generalities are functions of design. Shovels could match draglines and do in midwestern coal mines.

There is an increasing tendency for surface coal mining operations in the Northern Great Plains states to look toward "truck and shovel" operations. The phrase refers to the use of small electric- or diesel-powered shovels which remove overburden and load it into trucks, often rear dump trucks, for hauling to dump sites. Since delivery times for large equipment are long, the use of smaller equipment allows the operators to achieve production of shallow, thick coals; that is, the Northern Great Plains coals, within a shorter start-up time than possible with draglines. Further, truck and shovel operations allow greater mining flexibility and can facilitate reclamation by selective dumping and spreading of earth materials. It seems possible to initiate a major "truck and shovel" operation in about one year considering only the time required to obtain equipment and place it into operation.

In other cases, all overburden removal is accomplished with equipment also suited for road construction -- namely scrapers and dozers. Scrapers and dozers (tractor", "cat", "blade", "bulldozer", etc.) are a part of almost every major mine's equipment roster. They are usually used to remove, possibly to stockpile, and to place soils. They are used to rehandle spoil after dumping by dragline or shovel. These activities are in addition to "clean up" behind a dragline or shovel and access or haul road construction. In the case of the Big Horn #1 Mine, North of Sheridan, Wyoming, overburden and partings from the South pit are removed entirely by scrapers. If the overburden is sufficiently soft not to require blasting prior to removal or if when blasted, the overburden is relatively fine, the mine could depend upon scrapers for the majority of the earth movement.

Bucket wheel excavators (BWE's) may be used to remove either overburden or coal. BWE's consist of a series of shovel buckets, perhaps eight, arranged around a large diameter wheel which can dig up into relatively unconsolidated material and dump the material onto an articulated conveyor system designed to either transfer to another conveyor or to load trucks or trains. BWE's cannot operate efficiently in indurated (hard) material or material containing boulders. Nor can one generally expect to blast material and then remove it with BWE's. A BWE was reported used without success during the initial mining of the Glenharold mine (Colsolidation Coal Company) in Western North Dakota. A BWE type of machine started operating in the Belle Ayr South Mine (AMAX Coal Company), South of Gillette, Wyoming in 1975. The Belle Ayr South operations have involved BWE excavation of both coal and overburden. This equipment is more a bucket wheel loader compared to the BWE's in use in Europe or in the midwestern United States. It has been reported the BWE design modifications show promise for the equipment used for coal in the Belle Ayr South Mine. It is reported to increase the loading rate for coal considerably.

In the West, shovels, generally of moderate size, are used to remove coal. Coal shovels and front-end loaders fill trucks which haul the coal to a central preparation (crushing) and transfer point. Small draglines can also be used to load coal, but this might be considered only when the coal or "underburden" (geologic strata underlying the coal) is not strong enough to support the coal shovel or coal hauling equipment. At certain mines, some coal is left in the mine as support for the spoil dumped in the low wall* side. An inverted "V" - shaped ridge of coal left on the low wall side allows spoil to be piled higher and/or closer to the working pit.

Coal is hauled from the pit using off-road trucks with capacities ranging up to 200 tons (about 90 cubic yards). Truck haul distances vary and may end at power plants or, more frequently, at rail loading facilities. Eight to ten miles is currently considered the economical limit for truck haul. Trucks are generally diesel-fueled, although some gasoline-fueled equipment remains. Many of the coal haul trucks use electric motor drives powered by diesel engine-driven generators. Bottom-dump trucks are common. A few end-dump trucks are in operation, but the newer ones are used for hauling overburden.

When more than one bed of coal is mined, the parting material separating the beds may be removed using a dragline if the parting is sufficiently thick; scrapers or front-end loaders are used where the parting is thinner. Thick partings are usually blasted. Thin hard partings may be ripped by dozers and loaded into trucks.

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*Low wall refers to the side of an open pit adjacent to the previously mined area or what is generally the area of thinner overburden. "High wall" refers to the face of freshly exposed earth material not yet or not planned to be mined.

Most of the Western mines use rail transport for coal. Coal is dumped from the haul trucks into crushing equipment, sized to less than two inches, and delivered by a short conveyor system to silos or other covered facilities for storage. Such storage is required to permit quick loading of the trains and to even out mine production requirements. Trains are quite frequently loaded semi-automatically from the silos. Silo capacities are usually 10,000 or 12,000 tons, while individual rail car capacities are usually 100 tons. Thus, one silo can store sufficient coal to load a 100 car train.

Such trains are termed "unit coal trains"* in that they haul one comodity to a single location. Unit coal trains may be smaller or larger than 100 cars, but that number seems to be a frequent one for relatively long hauls. Increasingly common destinations for such trains are barge-loading facilities in the Midwest.

An important consideration when shipping coal long distances is the BTU content or heat value of the material. The lower the heat content, the more it costs to ship a certain amount of heat. Similarly, with higher water content in the coal, the cost to ship a given amount of heat is higher. High water content can also cause problems in emptying coal cars in cold weather since the coal freezes in the cars. Fuel oil sprays have been used to mitigate this problem.

Coals mined from the Northern Great Plains are not now washed. However, since washing removes sulfur and upgrades the heat content of the coal, there may be some coal washing proposed in the near future. However, the initially low sulfur content, principally organic sulfur, constrains the efficiency of conventional washing in terms of sulfur removal. To the West, in the Rocky Mountain Province, many coals are or are proposed to be washed.

"Captive mines" or mines located near the coal conversion point often require fly ash and bottom ash to be dumped back into the surface pit. The gray color of the ash serves to identify it in photography. This material is then covered prior to seeding. At the Navajo Mine in New Mexico, a mine not photographically examined in this report, bottom ash is also used as an experimental mulch and soil conditioner over spoil. Experimental work has also been conducted in the Northern Great Plains.

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*Unit trains are dedicated to hauling a single commodity. Unit coal trains return to mines empty. Generally the same cars and motive power service one mine and one unloading facility and thus travel the same route at all times and seldom uncouple.

After spoils are dumped by the dragline or other equipment, they are graded to the planned post-mining configuration, with the exception of active haul roads which may intersect the graded areas at regular intervals. If appropriate and possible, soil material is respread over the graded spoil to enhance the potential for revegetation. The post-mining configuration acheived often has the appearance of rolling terrain in which a somewhat regular "wave length" and "frequency" of low hills is introduced into the topography. This occurs where the overburden to coal ratio is large; where the ratio is small, the configuration may be superimposed on a shallow basin. Post-mining slopes may be graded as shallow as 1:10 (vertical:horizontal) depending upon the post-mining land use plans. However, typical post-mining grades are 1:3 and 1:4. Of course, some areas are almost flat. Grading should be performed as close to the mining operation as does not physically interfere with the operation and so as to prevent erosion problems.

Final grading can, in select cases, involve the retention of high walls (vertical cuts), the creation or replacement of lakes or impoundments, and the creation or replacement of drainage paths. In certain instances haul roads are retained. Thus, the visual patterns displayed by aerial imagery of mined and reclaimed areas may be varied.

Grading may be followed by placement of soil amendments (fertilizer, soil conditioners such as gypsum) and the creation of small-scale surface configurations (e.g., dozer basins or terraces to retain water and seed and to limit erosion). Graded and seeded areas are generally fenced to limit grazing. Seeding is usually done using conventional agricultural equipment with seed drills preferred by most operators, though a return to broadcast seeding has been noted. Seedling transplant of shrubs or trees is not widely practiced. Mulching has been practiced at most mines with widely different results in terms of producing notable improvements in seedling emergence and soil stability. Hay and netting have been tried as mulches. Planting of annuals to provide stubble has been employed. Most recent visits show increased use of hydromulching using wood fibers.

Most agronomists are recommending careful reestablishment of native species as the most appropriate revegetation procedure. Such reestablishment does not preclude the use of non-noxious introduced species especially on a temporary basis. The reestablished vegetative ecosystems evidenced on aerial imagery of revegetated mined lands may thus be similar to the systems shown on undisturbed land, though some degree of regularity may initially be evidenced.

Seeding is rarely followed by irrigation at the mines examined in this report. The only large-scale commitment to irrigation at Western coal mines as a whole is the sprinkler system installed at the Navajo

Mine in New Mexico. Annual precipitation rates there of about 15 centimeters (6 inches) have necessitated the use of supplemental water for at least 1.5 years. This area, of course, is outside the Northern Great Plains.

Though vegetated areas may be recultivated, reseeded, refertilized, and harvested, the overriding activity following seeding is one of waiting to see if the desired vegetative ecosystem will develop and survive.

The physical disturbances of a mining operation are not necessarily limited to the mine site itself. Employee housing and service facilities, rail lines, roads, pipelines and power transmission lines all can make their mark. The physical effects of these activities are evidenced in various ways on aerial imagery. Similarly, land uses not related to coal mining provide visual contrasts that are obvious on aerial photographs. Fence lines are notable examples, especially where range management practices differ on sides of the fence.

CHAPTER 4

CHARACTERISTIC RESPONSES OF AERIAL PHOTOGRAPHY

Two forms of aerial photography are presented here. The principal form used is a print from the normal color process film. Experience suggests that true-color imagery provides more information to the typical area than does black and white photography. Any land characteristics differing in visible color are detected on the film and the grays of black and white are further differentiated into the hues of the visible spectrum.

The second type of film used for this report is "color-infrared" or "false color." This film responds also to electromagnetic or infrared (IR) radiation (longer wave length) beyond the red limit of the visible range or, quantitatively, out of the 1,100 nanometer wave length*. Color as well as black and white IR are possible. Color IR imagery is collected through a yellow filter (filters out lower wave length blue) which assists in the shift of greens to blues on color IR positives. The IR radiation shows as red on the film. What is normally red becomes green. Principal "false" colors for Western mines flown with color IR are hues of red and blue respectively, then, IR and green. The red is response to IR energy reflected from that part of vegetation dependent upon moisture for its health. Thus, a bright red or magenta color on color IR prints is indicative of higher soil moisture (unsaturated) or even ground water (saturated) supplying the vegetation. Water can appear black on color IR film if the angle of view is right since water absorbs IR radiation. Color IR tends, obviously, to enhance detection of healthy vegetation and water boundaries. Color IR can therefore reflect degrees of vegetative stress.

There are, of course, limitations to the use of aerial photography. Weather is obviously an important factor. Planning is necessary to insure adequate coverage of the area. Film and print processing require professional assistance. Knowledge of climatic conditions preceding image acquisition is most useful. Above all, the photography will not answer all questions and it may raise some. Therefore, field work to collect ground truth data will still be required.

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*This range is short of the heat-sensitive range for thermal IR sensing (8,000 to 14,000 nanometers).

Finally, the aerial photography shows large-scale contrasts in the geology of the areas. Contacts between geologic formations often provide striking linear contrasts. The different formations also produce different soils which then support different vegetative species.

TABLE 2 - General Specifications of Imagery Acquisition Systems

Date Photography Acquired	Specifications
1974	B-26 Aircraft (approx. 6,000 feet or 1,800 meters) RC-8 9-Inch Mapping Camera, 6 inch (15 cm) Focal Length Lens EK 2443 Color Infrared Film KA-76 5-Inch Reconnaissance Camera, 3 inch (7.6 cm) Focal Length Lens EK 2445 Aerocolor Negative Film
1975	High Altitude (approx. 56,000 feet or 17,000 meters) NASA RB-57 Aircraft ZEISS 9-Inch Mapping Camera, 12 inch (30 cm) Focal Length Lens EK 2443 Color Infrared Film ZEISS 9-Inch Mapping Camera, 6 inch (15 cm) Focal Length Lens EK 2402 Plus X B&W Negative Film
1976	Low Altitude (approx 6,000 feet or 1,800 meters) NASA P3A Aircraft ZEISS 9-Inch Mapping Camera, 6 inch (15 cm) Focal Length Lens EK 2443 Color Infrared Film ZEISS 9-Inch Mapping Camera, 6 inch (15 cm) Focal Length Lens EK S-397 Ektachrome Aerographic Film

This report provides a brief summary of one detailed computer analysis of satellite imagery analyzed in a similar fashion for the majority of the mines in the Northern Great Plains area. A more extensive presentation of the analysis procedures and results thereof may be obtained in the referenced report prepared by the EPA National Field Investigation Center in Denver.*

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*EPA National Field Investigation Center, "An Application of ERTS Technology to the Evaluation of Coal Strip Mining and Reclamation in the Northern Great Plains," Feb., 1975.

CHAPTER 5

INVENTORY OF SURFACE COAL MINES IN THE NORTHERN GREAT PLAINS

This chapter provides a graphic inventory of major coal mine sites present in the Northern Great Plains area of Montana, North Dakota, and Wyoming. The graphic inventory takes the form of color aerial photography presented in an introductory fashion as a technique that has applicability to planning and regulation of coal mining. The principal photography was collected in July of 1974. The 1974 imagery was collected by the EPA Environmental Monitoring and Support Laboratory in Las Vegas, Nevada using the equipment noted in Table 2 at altitudes close to 1,800 meters (6,000 feet). The remainder of the imagery is comprised mainly of color-infrared photography flown in 1975. This later imagery was collected while flying at an altitude of approximately 17,000 meters (55,000 feet). The lower altitude photography was collected to provide a high degree of resolution, and to thus provide some ground data* in the photography itself. However, the lower altitude photography is more cumbersome to handle in that numerous frames have to be mosaicked** or otherwise combined to obtain the desired perspective of a mine covering a large area. The higher altitude photography often embraces a single surface mine on one frame, thus allowing, if adequate spatial resolution is achieved, expeditious enlargements of the imagery to various scales compatible with other data such as that contained in topographic maps.

Near infrared (IR) aerial (or "color infrared") imagery was collected on color IR film simultaneously with the low altitude color imagery but is not presented in its entirety since the additional photography would require more extensive interpretation than is available for this report. This chapter presents color IR-instigated (or "false color") imagery for selected mines to enable the reader to make some comparisons between the true and false color imagery. The high altitude photography collected in 1975 and presented in this report is also color IR.

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*Ground data, also called ground truth data, refers to data that identify the vegetative species, soil types, mining procedures, types of equipment, land uses, or other land surface characteristics that produce a visual pattern on the photography but which, on higher altitude photography, cannot be completely or accurately defined.

**Mosaic refers to the careful cutting of individual photographic prints along visual-lineations or other natural marks to produce a composite aerial photograph covering a large area. Using principally the center of each print reduces the distortion of the image and facilitates matching.

Along with the aerial imagery are presented tabulated summaries of technical information describing the mining activity. Perhaps the greatest value of that information will come if the technical information is regularly updated and verified. The data are considered preliminary at this stage, but are presented for two reasons. First, the photography shows varied visual appearances caused both by the physical environment and the mining practice. The summaries may help to explain some of the differences. Second, it is necessary to provide statistics that can be used, albeit carefully, to estimate, for example, the numbers of people involved in the various mining situations, equipment requirements, and transportation arrangements. The data were obtained from numerous sources and at various times. In obtaining the data, we attempted not to impose upon the already full schedule of the operators any more than we had already. Only in North Dakota did we go to the operators (through the North Dakota REAP*) to refine the information. The Bureau of Mines** of the U.S. Department of the Interior has adopted a system that is capable of keeping track of this descriptive information as the information characterizes technical considerations, areas affected, and equipment used at a mine site. Operators are therefore encouraged to refine these data and provide them on a regular basis.

Plate 1 (in rear pocket) is a location map for the mines inventoried.

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*REAP stands for Regional Environmental Assessment Program. This organization was formulated by North Dakota State Legislature.

**Intermountain Field Operations Center, Denver, Colorado

Section 5-1
Dave Johnston Mine - Plates 2 and 3

The Dave Johnston Mine, or "Dave Johnston Fuel Recovery Pit" as it is formally called, takes on the appearance of a snake and is represented here in both true color and color infrared photography. The true color photograph (Plate 2) is a low altitude mosaic collected on 29 July 1974. The color infrared film was exposed at an altitude of 17,450 meters (57,200 feet) on 28 January 1975. The mine is also the subject of an investigation of the applicability of satellite imagery (See Chapter 6). This mine is considered a "captive mine" and ships coal by rail to the Dave Johnston Power Plant nearby at Glenrock, Wyoming.

The effects of more arid climate limit the infrared photographic response to vigorous vegetative growth in the 1975 photography of this mine. However, the varied vegetation and earth patterns along the southwest side of the mine reflect the vegetation and reclamation efforts. Along the extreme south-southwestern edge, the rows extending out from roads represent areas from which soil was removed for use over the older spoils. The 1974 lower altitude photography shows only tinges of green in the revegetated areas. The remainder of the affected land looks not too unlike the undisturbed lands except in terms of density of vegetative growth.

The mined area northwest of the mine offices and coal loading area and west of the eastern extension of the mine was seeded in 1969. Progressing northwest, areas were reseeded in 1970, 1971, 1972, and 1973. Most of the mined areas with vegetation to the southeast were seeded in 1972. Note the termination of drainage channels by the mine as shown in the plates.

Comparison of the two photographs (Plates 2 and 3) facilitates an assessment of mining and reclamation progress. The separate pit on the northeast side of the mine has progressed north and east and additional excavation has been performed preparatory to mining the deeper bed. Grading activities east of the loading area have been extended toward the pit and emergent vegetation can be seen north of the loading area near the pit. In the newer pit area, spoil has been placed on the highwall side (Plate 3).

DESCRIPTION OF MINE

1. Mine: Dave Johnston Fuel Recovery Pit

2. Location: State: Wyoming County: Converse Township: 36N
(all acreage on which present corporate owners have conducted or are conducting operations)
Range: 75W Sec: 21,28,33,24
County: Converse Township: 36N
Range: 74W Sec: 3, 10, 11

3. Mine Operators: Pacific Power and Light Company

4. Production Rates: For Year 1974: 2,897,383 tons per year
Estimated or Projected for Year 1974: 2,687,045 tpy
Monthly Average for 1974: 224,000 tons per month

5. Destination of Coal: (A) Estimated tons per year (2,687,045) to
Glenrock, WY, Dave Johnston Plant (EGS) 750 MW
City, State Use

6. Description of Long-Haul Transportation (reference 5 above):
(A) None (e.g., unit train), Ownership: ________
________, # Cars ____ per train
(B) Yes (e.g., unit train), Ownership: Pacific Power and Light Company, # Cars ____ per train
Approximate rate of car loading ____ min. per car (100 ton)
Storage Capacity for Loading ____ tons

7. Stratigraphic Data:
(A) Average Overburden Thickness 110 feet; range 60' to 200 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)

Badger	16'
School	37'

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
145', ____, ____
Deeper Seams ________ ____
thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average 140', Maximum: 180'
Minimum: 80'
(E) Bulking Factor for Spoils: ____% (measured; estimated)

8. Major Operating Equipment:

	model	capacity		power rqmts
Draglines:	Page 752 LR	39 (cuyd)	261 (ft) boom length	____ (kw)
Shovels:	BE-150-B	10 (cuyd)	43 (ft) max. radius	350/875 ([illegible])
	Marion 151M	14 (cuyd)	____ (ft) max. radius	____ (kw)

	number	model/power	capacity	
Trucks:	4	LW (Rear dump)	65	(tons)
	1	Dart (Rear Dump)	65	(tons)
Scrapers:	1	Euclid		(cuyd)
	1	L/W Self-loading B70		(cuyd)
	1	Terex S-24		(cuyd)
Dozers:	3	Cat D9 Dozers		(cuyd)
	1	Cat 14 Grader		(cuyd)
	1	Austin Western 3000 Grader		(cuyd)
Drills:	1	B40L-22 Coal Drill		(cuyd)
Front End: Loaders	1	Michigan 275B		(cuyd)
	1	Cat 950		(cuyd)
	1	Michigan 275B		(cuyd)
	Yes	?	?	(cuyd)
Water Trucks:				(cuyd)

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 96

109 in July, 1974

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ________, In Headquarters: ________

(C) Contract Labor: Average for 1973: ________, % of year worked ____%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number
Glenrock	
Douglas	
Casper	

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: __________%, State: __________%, Private: ____________%

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: W038597,W041355, State Permit: ____________________ (if any)

W0244167, W0312918

W038602, C054769

12. Disposition of Surface in July 1974: **Estimated from Photography.**

(A) Active Pit and "Active" Spoils: 612 acres (including areas leveled for dragline or shovel) **(300 ac. pit and spoils alone)** **(Includes scraped areas and miscellaneous disturbed land.)**

(B) Spoils Regraded or Being Regraded: 640 acres **Total A+B=1252 acres**

(C) Revegetated (Seeded and for Growing): 500 acres **(Portion of graded area (B))**

(D) "Orphan Spoils" and Open Water: (27) acres **(This acreage is within active pit areas and is limited to ponded water.)**

(E) Support Facilities, Transportation Routes: > 65+ acres **(doesn't include transportation)**

TOTAL disturbed acreage (A+B+E) = 1317 acres

13. Average Analyses of Coal:

Name of Coal Seam School, Moisture 22 %, Ash (wet) 11 %

Na_2O(Ash) .13 %, Sulfur (wet) .6 %, Btu (wet) 8200 per lb.

Name of Coal Seam Badger, Moisture 27 %, Ash (wet) 8 %

Na_2O(Ash) .13 %, Sulfur (wet) .45 %, Btu (wet) 7950 per lb.

Name of Coal Seam Average, Moisture 26 %, Ash (wet) 12 %

Sulfur (wet) 0.5 %, Btu (wet) 7800 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Estimated Reserves: 150,000,000 tons.

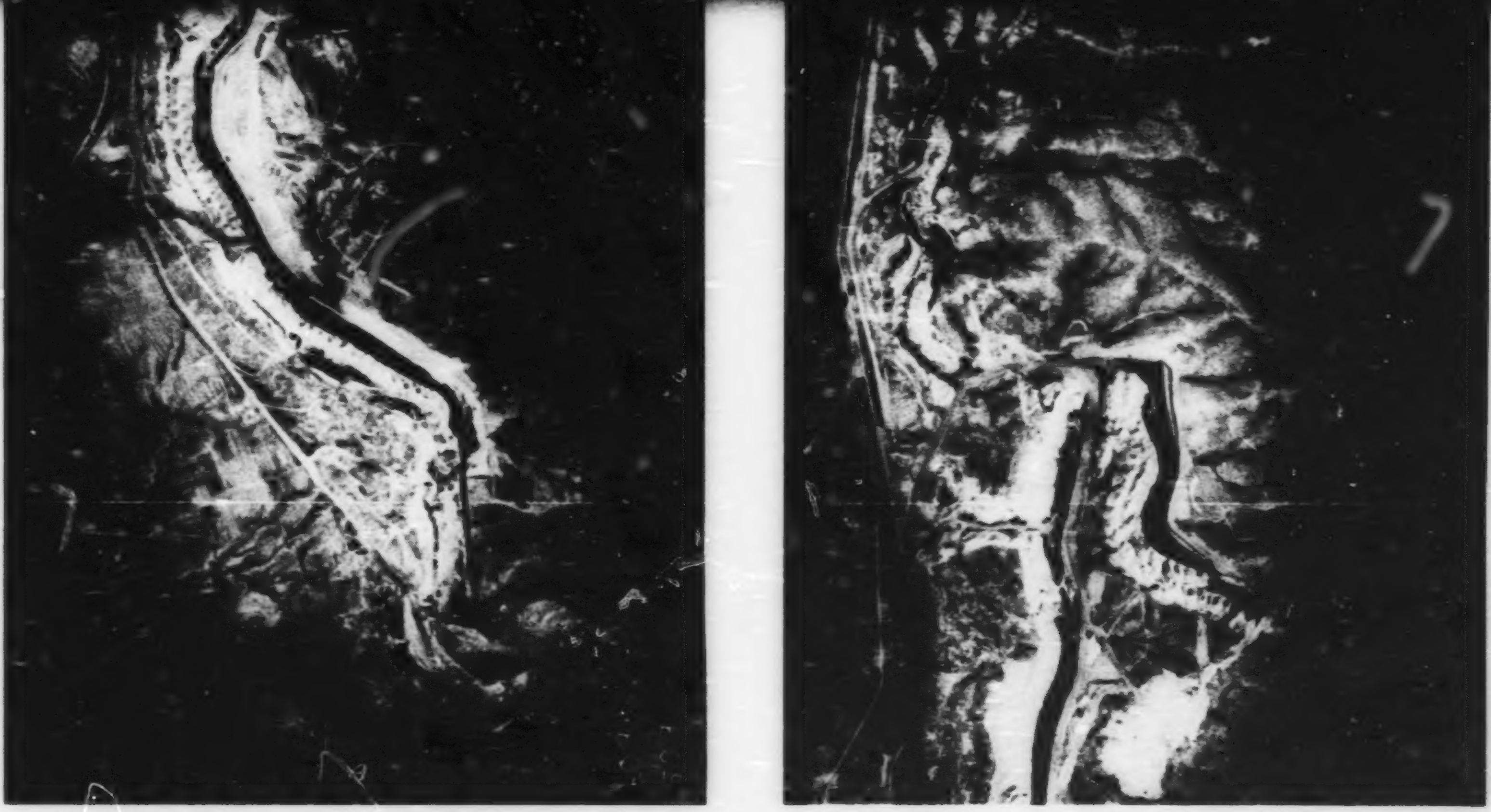
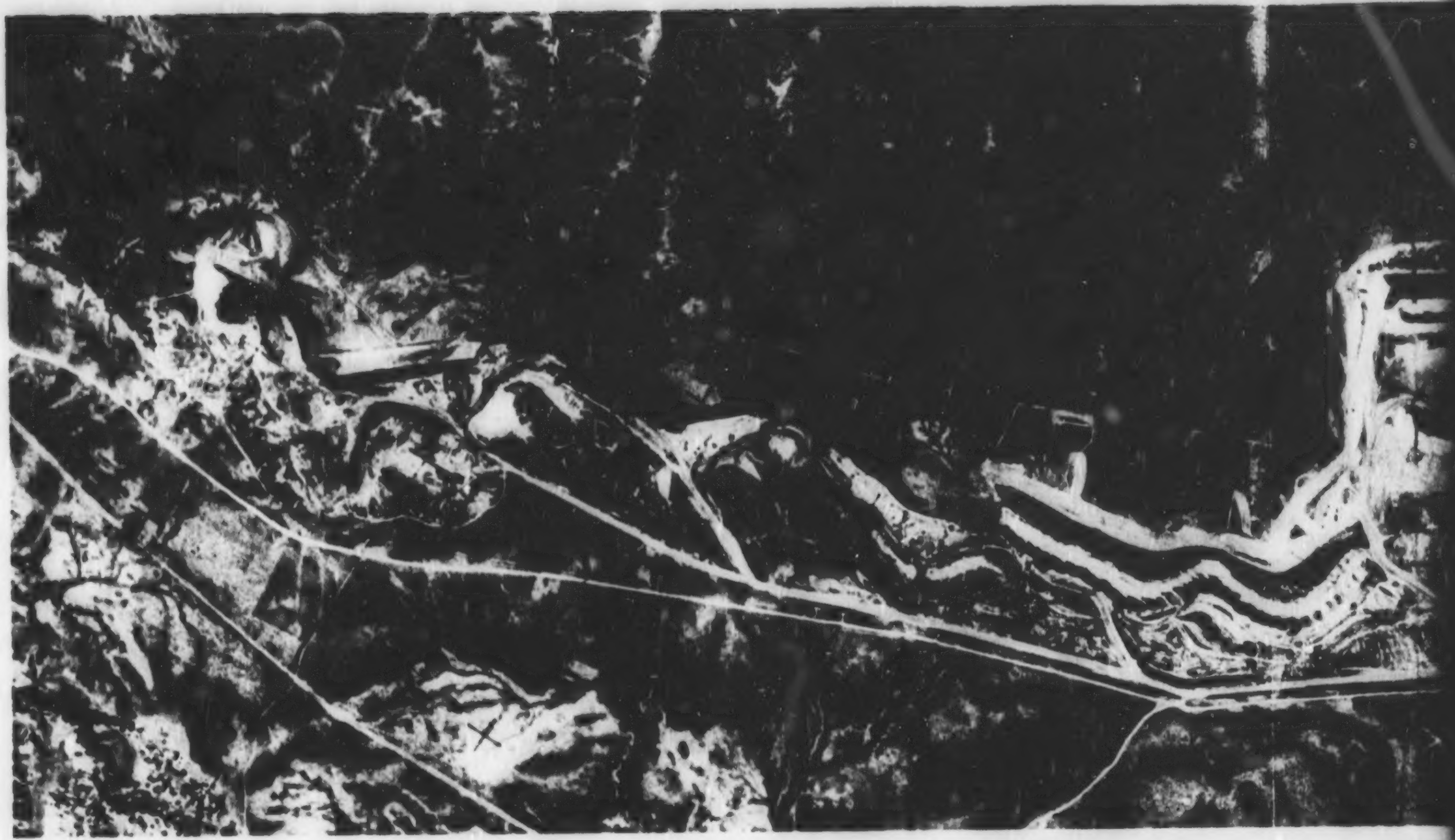


PLATE 2

DAVE JOHNSTON MINE
Pacific Power and Light
Converse County, Wyoming
29Jul74



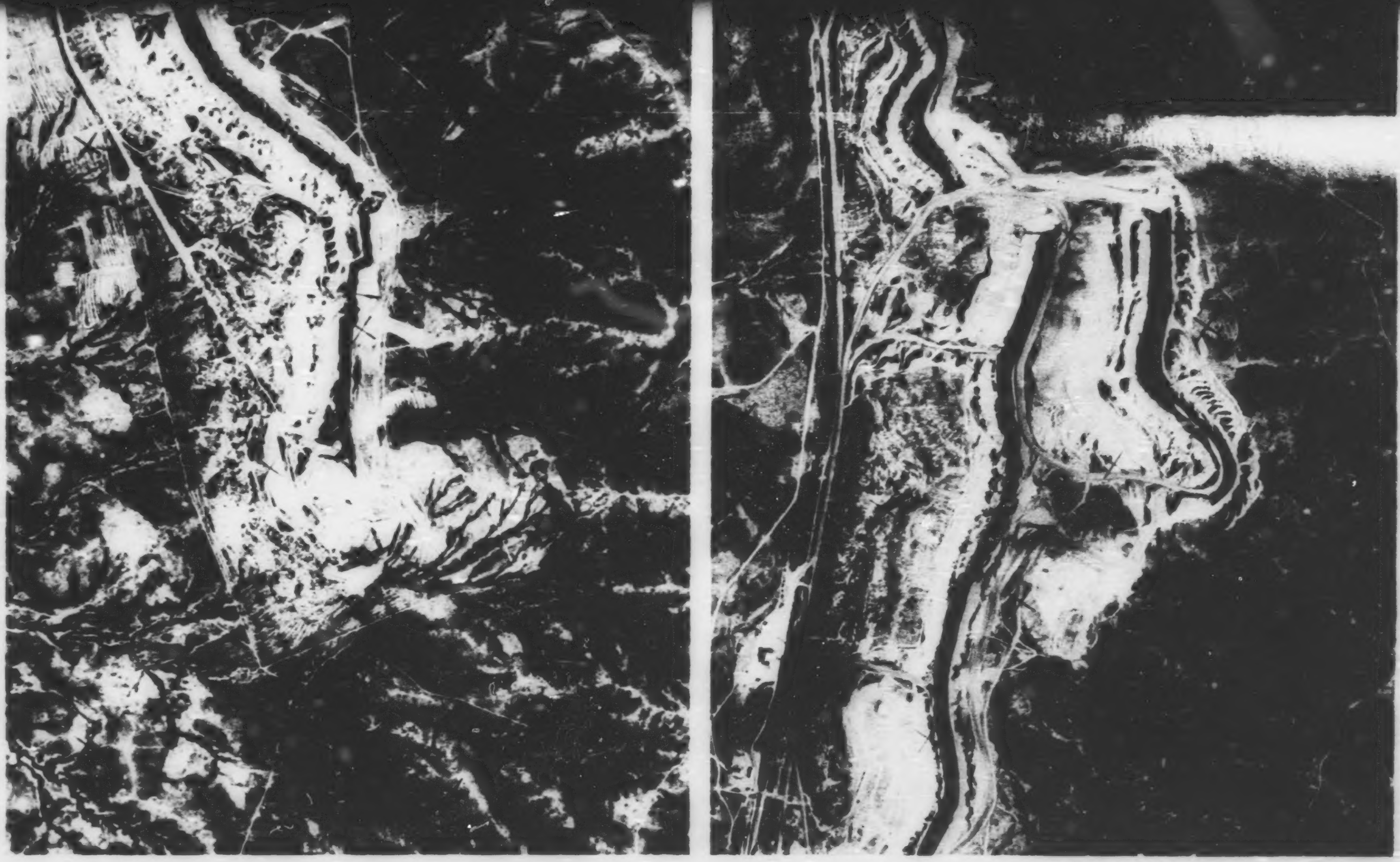

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PLATE 3

DAVE JOHNSTON MINE
Pacific Power and Light
Converse County, Wyoming
28Jun75 Color IR High Alt.

Section 5-2
East Antelope Mine - Plate 4

This mine is the small operation shown on the right of Plate 4, which is a mosaic of low altitude, true color photography collected on 19 July 1974. The water-filled pit to the west (left) is an abandoned coal mine. Obviously, the East Antelope operation is one of the smaller surface coal mines in the Northern Great Plains.

We have not yet determined the significance of the X-like mark located in the west center of the mosaic, but it continues to be of interest.

DESCRIPTION OF MINE

1. Mine: East Antelope

2. Location: State: Wyoming County: Converse Township: 41N
(all acreage on which present
corporate owners have conducted
or are conducting operations) Range: 71W Sec: 35

3. Mine Operators: Best Coal Company

4. Production Rates: For Year 1974: 1,195 tons per year

Estimated or Projected for Year 1974: None tpy

Monthly Average for 1974: None tons per month

5. Destination of Coal: (A) Estimated tons per year (____) to

Miscellaneous users in Wyoming - homes
City, State Use

6. Description of Long-Haul Transportation (reference 5 above):

(A) 1 (e.g., truck), Ownership: Best Coal Company

____, # Cars ____ per train

Approximate rate of car loading ____ min. per car (100 ton)

Storage Capacity for Loading ____ tons.

7. Stratigraphic Data:

(A) Average Overburden Thickness 30 feet; range 5 to 40 feet

(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
(called "D" coal also)

Anderson 35'

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
____, ____, ____ Deeper Seams 20-40' 35'
thickness and approximate separation from
mined seams.

(D) Depth of Active Pit: (feet) Average 40', Maximum: 60'

Minimum: 25'

(E) Bulking Factor for Spoils: ____% (measured; estimated)

8. Major Operating Equipment:

Draglines: None model, ____ (cuyd) capacity, ____ (ft) boom length, ____ (kw) power rqmts

Shovels: None model, ____ (cuyd) capacity, ____ (ft) boom length, ____ (kw) power rqmts

Trucks: 1 number, 5-ton gasoline model/power, 5 (tons) capacity

Scrapers: None number, ____ model/power, ____ (cuyd) capacity

Dozers: None number, ____ model/power, ____ (cuyd) capacity

Drills: None number, ____ model/power, ____ (cuyd) capacity

Front End Loaders: 1 number, small model/power, 1-3 (cuyd) capacity

Water Trucks: None (number), ______ (model/power), ______ (capacity) (cuyd)

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 1

1 in July, 1974

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ______, In Headquarters: ______

(C) Contract Labor: Average for 1973: ______, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

At Mine (Town) 1 (Number)

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: 100 %, State: ______ %, Private: ______ %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: B031719, State Permit: ______ (if any)

12. Disposition of Surface in July 1974: Estimated from Photography.

(A) Active Pit and "Active" Spoils: 6 acres (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: 0 acres

Total: A+B+C+D = 24 ac

(C) Revegetated (Seeded and for Growing): 0 acres

(D) "Orphan Spoils" and Open Water: 18 acres (4-acre pond included)

(E) Support Facilities, Transportation Routes: 3 acres

TOTAL DISTURBED ACREAGE: 27 acres.

13. Average Analyses of Coal:

Name of Coal Seam Anderson ("D"), Moisture 26 %, Ash (wet) 6 %

Sulfur (wet) .2 %, Btu (wet) 8650 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Pit does have to be pumped out prior to each year's operation - usually open October-March.

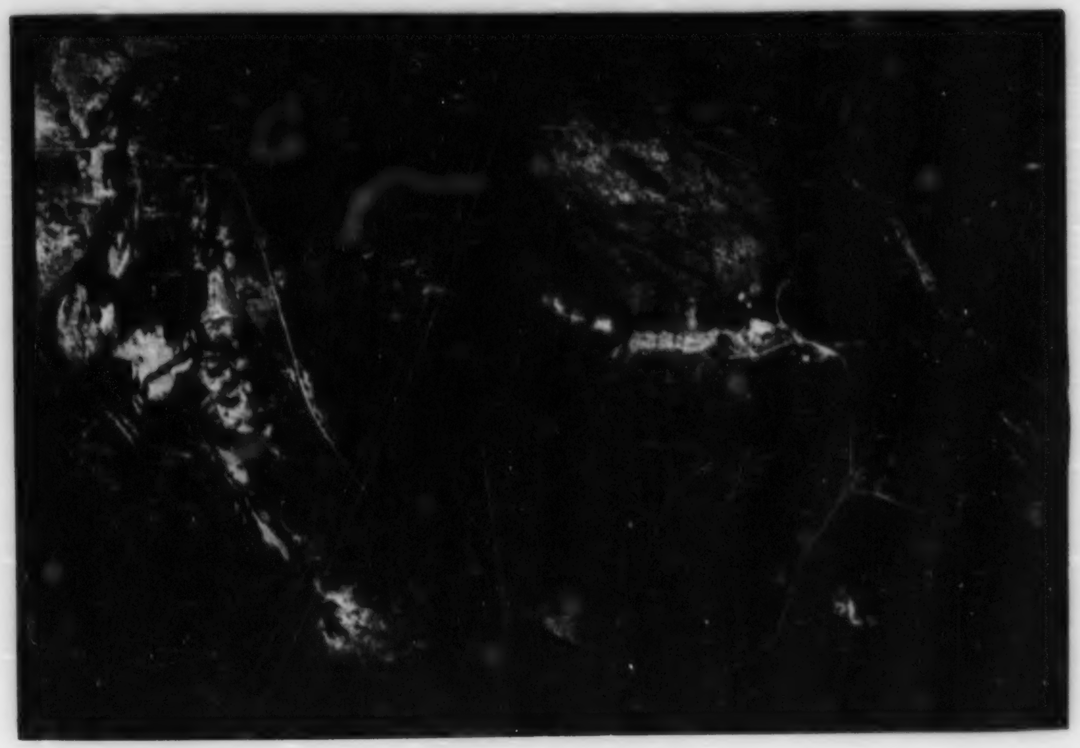

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PLATE 4

EAST ANTELOPE MINE
Best Coal Company
Converse County, Wyoming
19Jul74 1201-1202 hrs

Section 5-3
Belle Ayr South Mine - Plates 5 and 6

This mine is represented in two sets of aerial photography; true color flown on 29 July 1974 and color infrared collected from an altitude of 16,900 meters (55,500 feet) on 23 June 1975. The true color low altitude imagery is presented in mosaic form. The two imagery collection dates, almost one year apart, allow examination of the northward movement of the pit and the initial return of spoils to the southern part of the mine. Growth of perennial vegetation is evidenced in plots at the extreme southeast corner of the mine, but significant moisture availability to vegetation on disturbed lands is not evidenced elsewhere except along the haul road. The area east of the coal load silos has been seeded in the past and vegetative growth of annuals is visible in the 1974 photography, but not in the 1975 photography.

Caballo Creek has been diverted around the working pit on the west and south. The continued subsurface flow of water is shown by the magenta hues east of the south part of the mine in the 1975 photography. The availability of water to vegetation in the undisturbed valley of Caballo Creek is quite apparent. The pinkish color of roads and parking areas in the 1974 photography comes from baked shale or clinker used to surface the roads.

The soil patterns shown in both sets of photography are noteworthy. The yellowish area of the 1975 photography extending south-southeast from the mine is most likely related to the burn line of the coal bed and shows as a reddish tinge at the bottom of the 1974 imagery.

DESCRIPTION OF MINE

1. Mine: Belle Ayr - South (Presently "Belle Ayr")

2. Location: State: Wyoming County: Campbell Township: 71N
(all acreage on which present corporate owners have conducted or are conducting operations)
Range: 48W Sec: 34,35

3. Mine Operators: AMAX Coal Company

4. Production Rates: For Year 1974: 867,544 tons per year

Estimated or Projected for Year 1974: 3,301,472 tpy

Monthly Average for 1974: 275,000 tons per month

5. Destination of Coal: (A) Estimated tons per year (1,300,000) to

Pueblo, Colorado Commanche Plant (EGS)
City, State Use
(Public Service of Colo. - 350 MW Sta)

(B) Estimated tons per year (1,000,000) tp

Denver and Boulder, Colorado (EGS)
City, State Use
(Public Service of Colo.)

(C) Estimated tons per year (500,000) to

Burlington, IA (EGS)
City, State Use
(Kansas City Pwr & Light - Burlington)

(D) Estimated tons per year (500,000) to

East St. Louis MO to barges (EGS)
City, State Use

6. Description of Long-Haul Transportation (reference 5 above):

(A) 4 Destinations (e.g., unit train), Ownership: Burlington - Northern, # Cars 100-124 per train

Approximate rate of car loading 1 min. per car (100 ton)

Storage Capacity for loading 24,000 tons two silos plus 2 under construction. primary crusher to 4", secondary crusher to 2" topsize

7. Stratigraphic Data:

(A) Average Overburden Thickness 35 feet; range 20 to 60 feet
(Max 200' in future) (Soft, sandy shale)

(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)

Anderson-Canyon 70'
(also called Roland-Smith or Wyodak Coals)

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)

Few inches to no visible partings.

Deeper Seams thickness and approximate separation from mined seams.
(underlain by hard, sandy shale)

(D) Depth of Active Pit: (feet) Average 105, Maximum: 130

Minimum: -0-

(E) Bulking Factor for Spoils: ________ % (measured; estimated)

8. Major Operating Equipment:

Draglines: ____________, ______(cuyd), ______(ft), ________(kw)
model capacity boom length power rqmts

Shovels: 2 ea B-E 295B, 24 (cuyd), 55 (ft), 800/2000 (hp)
model capacity max. radius power rqmts

295B, 20 (cuyd), ______(ft), ________(kw)
model capacity max. radius power rqmts

Trucks: 5, Dart - Diesel Dumps, 75 (tons)
number model/power capacity
(17 each end dump 120 ton)

8, Lectrahauls 1000 HP, 120 (tons)
number model/power capacity

1, Terex End Dump, 170 (tons)
number model/power capacity

Scrapers: ______, ____________, ________(cuyd)
number model/power capacity

Dozers: 3, Michigan Dozers, ________(cuyd)
number model/power capacity

1, Motor Grader Mod 12, ________(cuyd)
number model/power capacity

Drills: 1, Coal Drill (from Wyodak), ________(cuyd)
number model/power capacity

Front End Loaders: 1, Cat 988, ________(cuyd)
number model/power capacity

2, ____________, 10,000 gal (cuyd)
number model/power capacity

Water Trucks: ______, ____________, ________(cuyd)
number model/power capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 28

51 in July, 1974 2 shifts, 6 days
June 75 88

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ____________, In Headquarters: ____________

(C) Contract Labor: Average for 1973: ________, % of year worked ____%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Gillette, Wyoming ____________
Town Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: 76 %, State: ______%, Private: 24 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: Wyoming 0317682, State Permit: ______
(if any)

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: 71 acres (includes 10 acres of topsoil storage and 9 acres miscell.)
(including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: 100 acres

(C) Revegetated (Seeded and/or growing): 100 acres

(D) "Orphan Spoils" and Open Water: 1 acre pond acres (included in regraded figure)

(E) Support Facilities, Transportation Routes: 46 acres

Total Disturbed Acreage: 217 acres

13. Average Analyses of Coal:

Name of Coal Seam: Wyodak; Moisture: 30.4%; Ash: 6.4% (wet)

Na_2O Ash dry: 1.27%; Sulfur (wet): 0.48%; BTU (wet): 8020 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Reportedly pump 90 gallons/minute for dewatering of mine
Reserves estimated 300,000,000 tons
Blasting ANFO or slurry - coal only
4:1 or 3:1 slope on spoiled overburden
Pumping about 100,000 gpm from pit
Caballo Creek diverted, Creek bed filled in part
Wheat grasses and sweet clover - 15 acres in 1972 (Spring)
    65 acres seeded in Fall 1973
Inside rail loop: Spring 1973 - 35 acres seeded with Western Wheatgrass
    and four-wing salt brush
Annual precipitation: 15"
Bucketwheel loader undergoing tests - Mechanical Excavators, Inc.

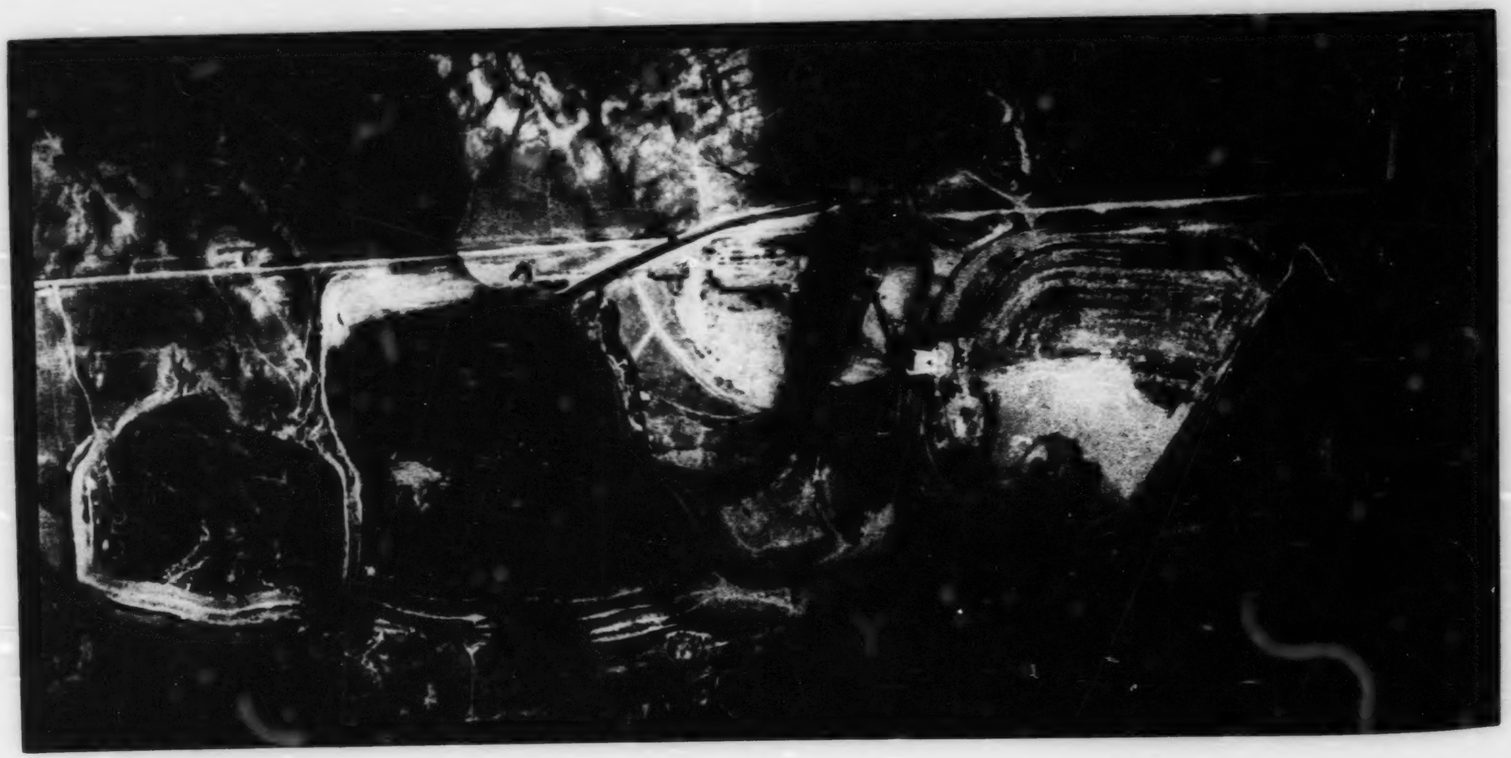

PLATE 5

BELLE AYR MINE
AMAX Coal Company
Campbell County, Wyoming
29Jul74 1020-1021 hrs

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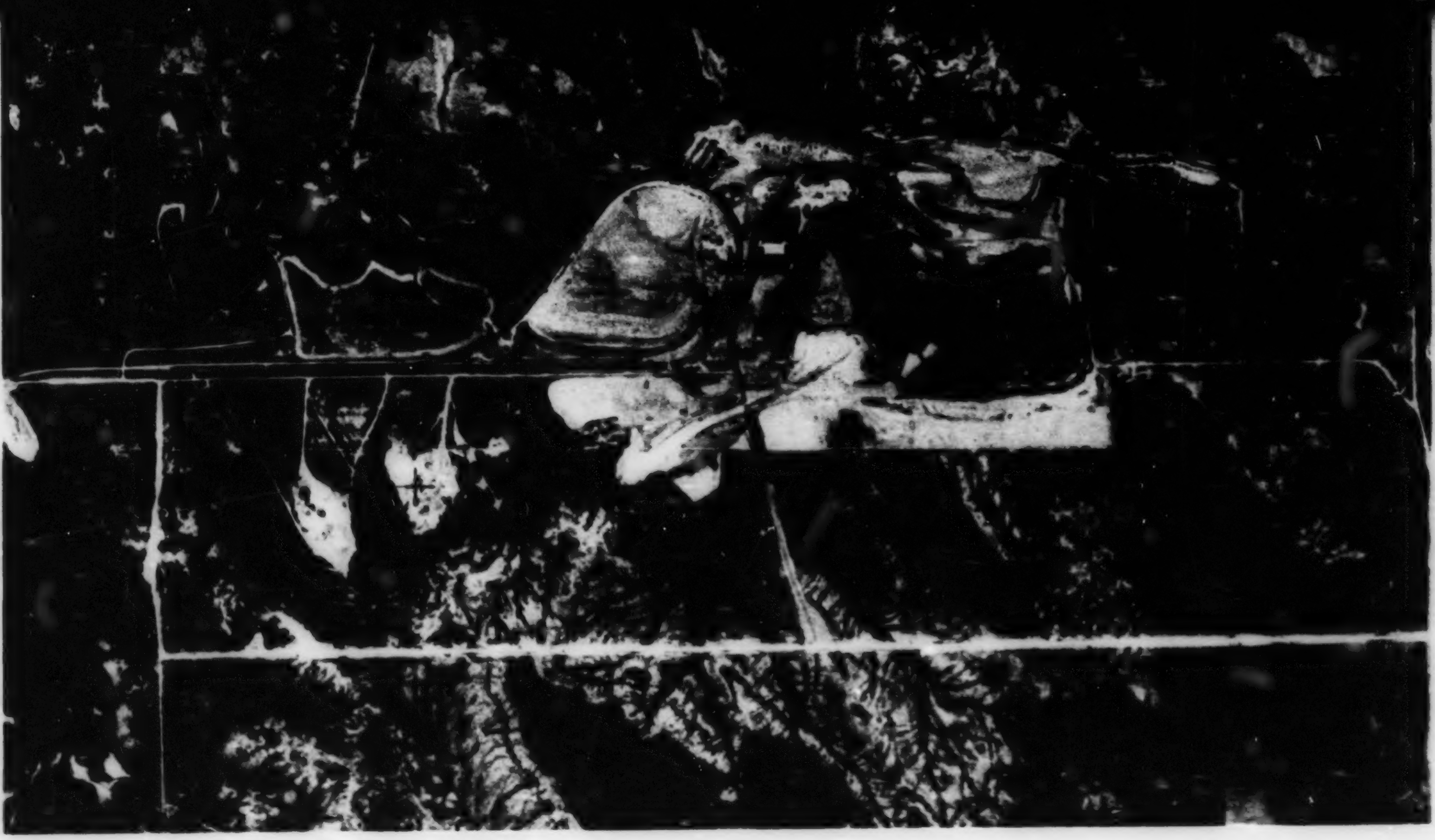
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PLATE 6

BELLE AYR MINE
AMAX Coal Company
Campbell County, Wyoming
23Jun75 Color IR High Alt.

Section 5-4

Wyodak Mine - Plates 7 and 8

This mine is represented in low altitude photography collected on 19 July 1974 (Plate 7). The active pit is that lying south of the highway. Obviously, the coal is thick and mining equipment requirements are minimal to date. The mine is also shown in low-level oblique color photography flown on the same day (Plate 8).

The Neil Simpson power plant lies between and to the east of the two mine pits with some grading evident east of the plant which is related to the plant's expansion. Some grading and subsequent vegetative growth is shown by the green vegetative hues on the north of the south pit and the south of the north pit. In 1974-5, this mine was operating in the thickest coal (two beds with minimal partings aggregating 24 meters or 80 feet) currently mined in the Northern Great Plains and probably in the United States.

The green color of Donkey Creek is related to algae nourished by sewage effluent from the town of Gillette. Seepage into the Wyodak Pit from the diverted creek has been noted.

DESCRIPTION OF MINE

1. Mine: Wyodak Mine - Wyodak South Pit

2. Location: State: Wyoming County: Campbell Township: 50N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 71W Sec: 27,28

3. Mine Operators: Wyodak Resources Development Corporation

4. Production Rates: For Year 1974: 727,019 tons per year

Estimated or Projected for Year 1974: 738,248 tpy

Monthly Average for 1974: 61,500 tons per month

5. Destination of Coal: (A) Estimated tons per year (250,000) to

Osage, WY Osage Station EGS 34.5 MW
City, State Use
(Black Hills Power & Lght)

(B) Estimated tons per year (230,000) to

Wyodak, WY Niel Simpson Station EGS 26.8 MW
City, State Use

(C) Estimated tons per year (130,000) to

Lead, SD Kirk Station EGS 31.5 MW
City, State Use

(D) Estimated tons per year (120,000) to

Rapid City, SD Ben French Station EGS 22.5 MW
City, State Use

6. Description of Long-Haul Transportation (reference 5 above):

(A) Conveyor to Steam Plant

(B) Yes (e.g., unit train), Ownership: Chicago and Northwestern, # Cars 25-30 per train

Approximate rate of car loading ____ min. per car (100 ton)

Storage Capacity for Loading 80 tons.

7. Stratigraphic Data:

(A) Average Overburden Thickness 30 feet; range 15 to 40 feet

(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
(also called Roland-Smith or Wyodak coal).

Anderson	40
Canyon	40

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)

0.7' to 1.5', "Mud"

Deeper Seams ____ ____
thickness and approximate separation from mined seams.

(D) Depth of Active Pit: (feet) Average 110', Maximum: 160'

Minimum: 85'

(E) Bulking Factor for Spoils: ____ % (measured; estimated)

8. Major Operating Equipment:

Draglines: 2 model, 2.5 (cuyd) capacity, Clam Shell boom length, ______(kw) power rqmts

(not used)

Shovels: None model, ______(cuyd) capacity, ______(ft) max. radius, ______(kw) power rqmts

Trucks: 1 number, ______ model/power, 25 (tons) capacity

5 number, Euclid Diesel model/power, 20 (tons) capacity

2 number, Cat Diesel model/power, 70 (tons) capacity

(ordering 100 ton - going to conveyor from pit)

Scrapers: 2 number, Cat 621 model/power, 15 (cuyd) capacity

1 number, Road Grader Cat Model 12 model/power, ______(cuyd) capacity

Dozers: 3 number, Cat D8H & Cat D7E model/power, ______(cuyd) capacity

Drills: 1 number, Coal Drill Salem-McCarthy 108 model/power, 6" capacity

Front End Loaders: 1 number, Hough 400 model/power, 14 (cuyd) capacity

Water Trucks: 1 number, Ford model/power, 2000 (gal) capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 29

28 in July, 1974 one shift

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: None, In Headquarters: None

(C) Contract Labor: Average for 1973: None, % of year worked ___%

Type of work:

(D) Places of Residence of full-time employees (and approximate number residing there):

Gillette Town, ______ Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: 90 %, State: ____%, Private: 10 %

11. Coal Lease and "Permit" Numbers : (as of July 1974)

Federal Lease: W073289, W0111833, State Permit: ______ (if any)

W0313666, B037423

12. Disposition of Surface in July 1974: Estimated from Photography.

(A) Active Pit and "Active" Spoils: 73 acres (includes 16 acres in inactive North pit) (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: 55 acres

(C) Revegetated (Seeded and for Growing): 45 acres (portion of part B)

(D) "Orphan Spoils" and Open Water: 45 (orphan), 4 ac. pond acres

(E) Support Facilities, Transportation Routes: 9 acres (includes old power plant, but none of the new construction)

TOTAL DISTURBED ACREAGE (A+B+D+E) = 186 acres

13. Average Analyses of Coal:

Name of Coal Seam Anderson-Canyon, Moisture 28 %, Ash (wet) 5.9 %

Na_2O(Ash) 1.3 %, Sulfur (wet) .52 %, Btu (wet) 8300 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Recoverable coal 160,000,000 tons.
Blasting AN-FO with dynamite and primacord slurry, E-Cord & primer 24' spacing to 120' deep.
Annual precipitation 14".
Currently terracing but will slope.
Using crested wheat, western wheat grass, alfalfa, sweet clover.
Water enters both North & South Pits (total) at 150 gpm.

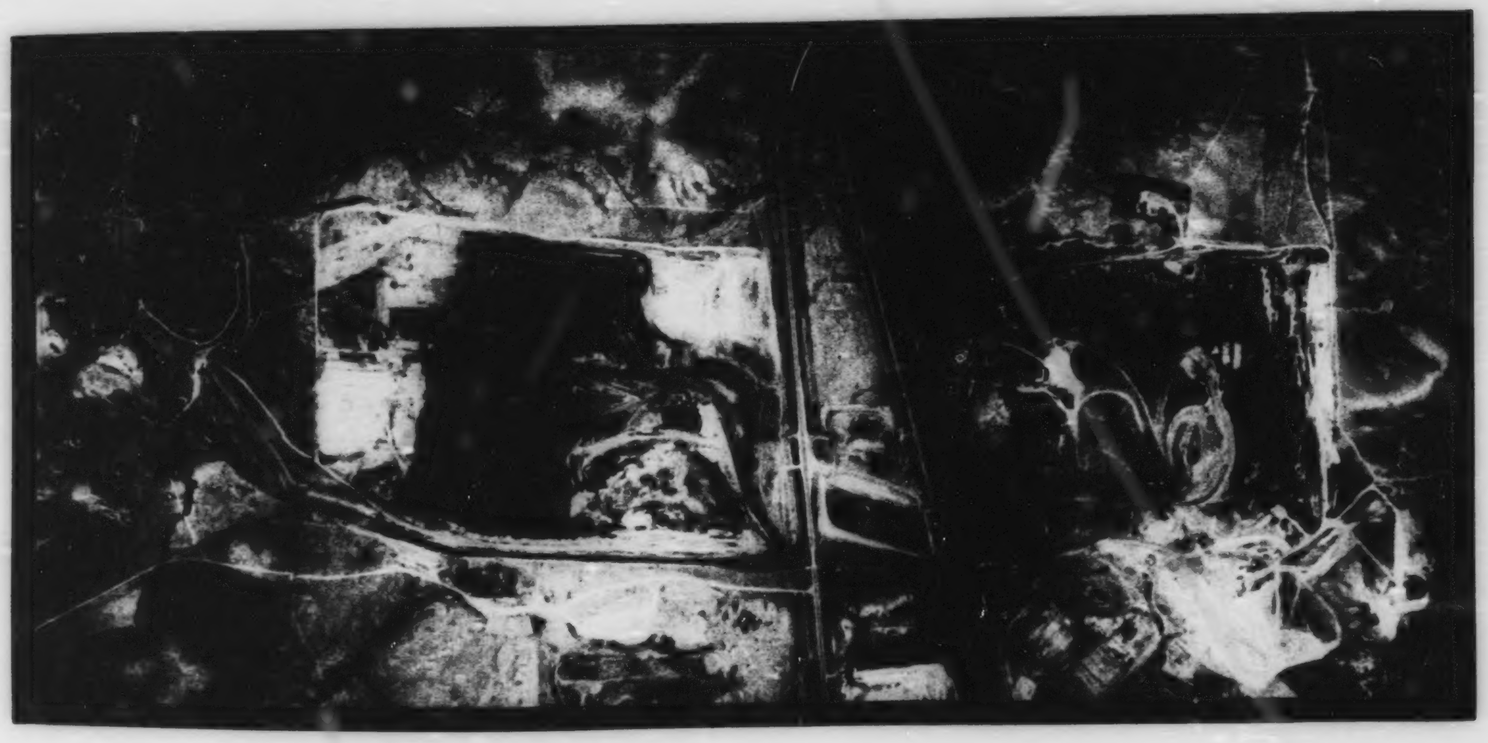

PLATE 7

WYODAK MINE
Wyodak Resource Development Company
Campbell County, Wyoming
19Jul74 1526-1527 hrs

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Photographs collected along south to north flight line. Horizon of photograph is west.

Continue to lower
photograph.

h to north
h is west.

PLATE 8

WYODAK MINE
Wyodak Resource Development Company
Campbell County, Wyoming
19Jul74 1530 hrs Oblique

Section 5-5
Welch Strip Mine - Plate 9

This is one of the smaller surface coal mines presently in operation in the Northern Great Plains. It is located in the Tongue River valley. The mine is viewed here through low altitude true color photography collected on 20 July 1974. The photograph (Plate 9) shows great distinction between the ground water dependent vegetation of the oxbow at the top of the photograph and the brownish cast of the range grasses on lands surrounding the mine.

Large portions of the mine have been graded but the darker gray color of the graded areas shows a relatively high concentration of waste coal (carbonaceous sandstone and shale) on the surface. Experiments performed at the Dave Johnston Mine have suggested that placement of such material on the surface materials can serve to complicate the revegetation process.

Surface drainage from the mined area appears along the north boundary of the disturbed lands and is impounded near there.

DESCRIPTION OF MINE

1. Mine: Welch Strip Mine

2. Location: State: Wyoming County: Sheridan Township: 57N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 85W Sec: 22

3. Mine Operators: Welch Coal Company (Subsidiary of Montana-Dakota Utilities)

4. Production Rates: For Year 1974: 18,708 tons per year
Estimated or Projected for Year 1974: 20,340 tpy
Average for 1974: 1700 tons per month

5. Destination of Coal: (A) Estimated tons per year (20,340) to
Acme, WY Acme Plant EGS
City, State Use

6. Description of Long-Haul Transportation (reference 5 above):
(A) None (e.g., unit train), Ownership: ____
____, # Cars ____ per train
(B) Yes - 1 (e.g., unit train), Ownership: Welch Coal Company, # Cars ____ per train
Approximate rate of car loading ____ min. per car (100 ton)
Storage Capacity for Loading ____ tons.

7. Stratigraphic Data:
(A) Average Overburden Thickness 50 feet; range 20 to 70 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
(Seam is split by many partings that are not mined.)
Monarch 13'
(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
<1', ____, ____ Deeper Seams ____ ____ thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average 70, Maximum: 80
Minimum: 30
(E) Bulking Factor for Spoils: ____ % (measured; estimated)

8. Major Operating Equipment:
Draglines: None (model), ____ (cuyd) (capacity), ____ (ft) (boom length), ____ (kw) (power rqmts)
Shovels: ? (model), 2-4 (cuyd) (capacity), ____ (ft) (max. radius), Gas or diesel (power rqmts)
(very old, not presently used)

	number	model/power	capacity	
Trucks:	1		5	(tons)
Scrapers:	1	Towed	Very Small	(cuyd)
Dozers:				(cuyd)
Drills:				(cuyd)
Front End: Loaders	1	Rubber Wheeled	small	(cuyd)
Water Trucks:				(cuyd)

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 3

2 in July, 1974

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ________, In Headquarters: ________

(C) Contract Labor: Average for 1973: ______, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number
Sheridan	

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ______%, State: ______%, Private: 100 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ________, State Permit: ________ (if any)

12. Disposition of Surface in July 1974: **Estimated from photography.**

(A) Active Pit and "Active" Spoils: 7.5 acres (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: 29 acres

(C) Revegetated (Seeded and for Growing): 12 acres **(remaining 17 acres have probably been seeded, but no evidence of revegetation.)**

(D) "Orphan Spoils" and Open Water: 1.1 acres **of ponded water**

(E) Support Facilities, Transportation Routes: .8 acres

TOTAL: A+B+D+E = 38.4 acres disturbed.

13. Average Analyses of Coal:

Name of Coal Seam Monarch, Moisture 19 %, Ash (wet) 11 %

Na_2O(Ash) 1.4 %, Sulfur (wet) 1.5 %, Btu (wet) 8900 per lb.

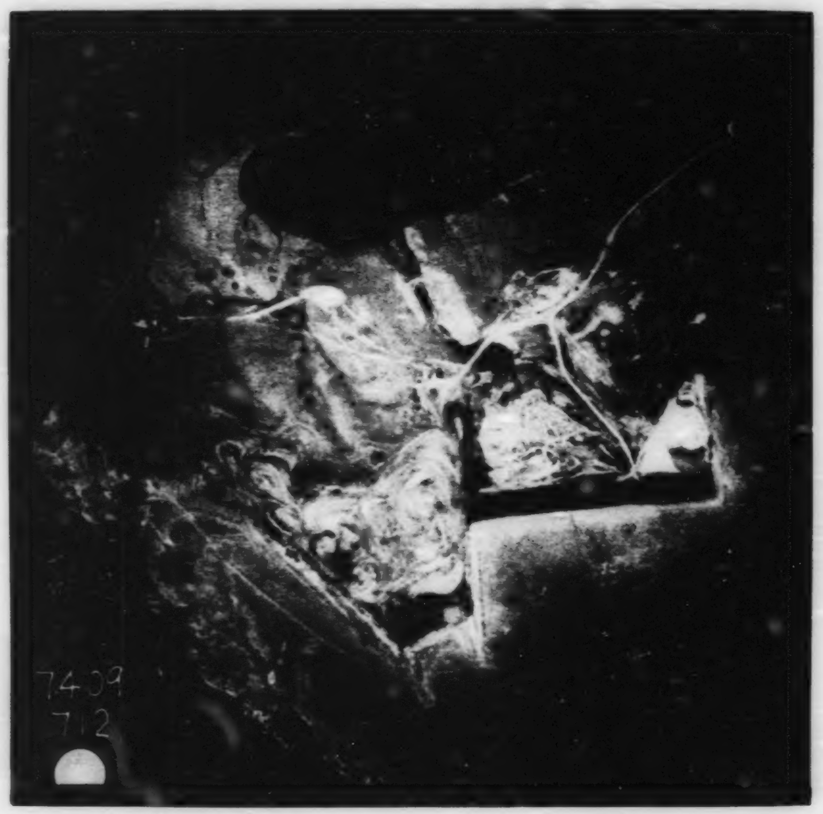
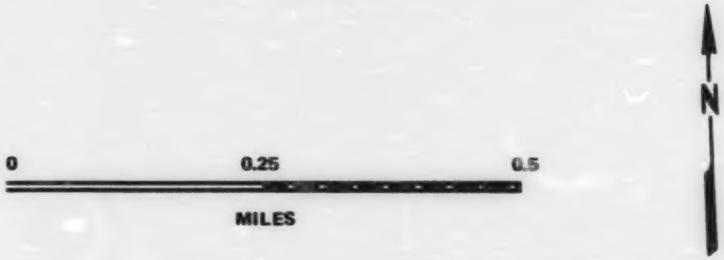


PLATE 9

WELCH STRIP MINE
Welch Coal Company
Sheridan County, Wyoming
20Jul74 1110 hrs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Section 5-6
Big Horn Mine - Plates 10 and 11

This mine is located north of Sheridan, Wyoming in the topographic valley of the Tongue River. It is represented in this report in low altitude true color photography flown on 28 July 1974. It is also shown in oblique and aerial photography flown the same day. The surface mining activity is located in the southeast corner of the intersection of the Tongue River and Goose Creek. In fact, Goose Creek and the Tongue River flow in part through open areas where coal was mined. The large pond in Goose Creek near the south edge of the mosaic is a mined-out area as are the rectangular ponds to the north of the Tongue River. The town of Acme, Wyoming lies near the center of the mosaic.

The northern part of the area shown is characterized by subsidence features resulting from collapse of underground workings in the same (age) coal beds not being surface-mined. However, little surface mining is being done in the areas that were once underground mined. Surface mining has not extended into these areas for a variety of reasons related to equipment problems, underground fires, and ownership of coal and surface.

The Big Horn Mine area also contains a large clinker (baked shale) recovery operation located to the west of the coal mine, across Goose Creek. One can see the reddish gravel-like material both at the mine and over the coal mine haul roads. Note also the extension of the reddish hue along both sides of the Tongue River. These are "burn lines" where coal outcrops have caught fire and left baked clay and shale and some clinker from the coal bed. This material is called "scoria" by some, but bears no relationship to volcanic processes producing scoria rock.

The portion of the mine to the south is a scraper-shovel-truck operation while the mine area to the north is a dragline operation to date. Grading and seeding activities are evidenced by the appearance of vegetative growth along the area between Goose Creek and the exposed coal. A varying density of growth is evident.

This mine has a potential to interfere with typical alluvial valley floor systems, but the south mined area is generally in a steeper area which rises abruptly from the drainage channels. If mining were feasible either to the west along the Tongue River or northeastward, then it would appear to compete, at least temporarily, with agricultural activities in the alluvial valley. It is not certain what lasting impact the mining may have on downstream water resources. The possibilities for increases in dissolved solids has not been assessed.

Encroachment upon the river is in evidence along the northeast edge of the mine at the time of collection of this photography.

In portions of the area currently mined and to the north of the area shown in Plate 10, extensive underground mining has been conducted. Subsidence features exist over hundreds of acres. Various areas of that coal are presently burning. Impressive columns of smoke are sometimes evident for short periods when portions of the old underground mines collapse up to the land surface.

DESCRIPTION OF MINE

1. Mine: Big Horn #1

2. Location: State: Wyoming County: Sheridan Township: 57N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 84W Sec: 15,22

3. Mine Operators: Big Horn Coal Company (Subsidiary of Peter Kiewit Sons, Company)

4. Production Rates: For Year 1974: 444,545 tons per year
Estimated or Projected for Year 1974: 997,274 tpy
Monthly Average for 1974: 83,000 tons per month

5. Destination of Coal: (A) Estimated tons per year (884,274) to
Kansas City, MO; Havana, IL; Acme, WY; Marshalltown,
City, State
IA; Mitchell, SD; Sioux Falls, SD; Aberdeen, SD (EGS)
City, State Use
(B) Estimated tons per year (113,000) to
Nebraska, Montana, Minnesota-Sugar & other industries
State Use
(to include cement)

6. Description of Long-Haul Transportation (reference 5 above):
(A) None (e.g., unit train), Ownership: ________
________, # Cars ____ per train
(B) Yes (e.g., unit train), Ownership: Kansas City - Burlington Northern, # Cars ____ per train
Approximate rate of car loading ____ min. per car (100 ton)
Storage Capacity for Loading ____ tons

7. Stratigraphic Data:
(A) Average Overburden Thickness 100 feet; range 15 to 200 feet
(0.5% dip)
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
Dietz Number 2 11'
Dietz Number 3 19'
Monarch 22'
(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
50, 20, ____
Deeper Seams 15' 80'
thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average 150', Maximum: 240'
Minimum: 40'
(E) Bulking Factor for Spoils: ____ % (measured; estimated)

8. Major Operating Equipment:

Draglines: B-E 450W, 12 (cuyd), 200 (ft), ____ (kw)
model capacity boom length power rqmts

Shovels: B-E 54B, 4.5 (cuyd), ____ (ft), Diesel
model capacity max. radius power rqmts

B-E 88B, 9 (cuyd), ____ (ft), Diesel
model capacity max. radius power reqmts

Trucks: 6, Euclid 105-W, Bottom dump hauler (lp gas), 50 (tons)
number model/power capacity

Scrapers: 8, 651 Cat, 32 (cuyd)
number model/power capacity

1, Euclid TTS-14, 28 (cuyd)
number model/power capacity

Dozers: 2, Cat D8H with ripper, ____ (cuyd)
number model/power capacity

3, Cat 12F road grader, ____ (cuyd)
number model/power capacity

1, Koehring 1066 backhoe, ____ (cuyd)
number model/power capacity

4, Cat D96 tractors, ____ (cuyd)
number model/power capacity

Drills: 2, Hardscog Drills BE 1-40R O/B Drill, ____ (cuyd)
number model/power capacity

Front End Loaders: ____, ____, ____ (cuyd)
number model/power capacity

Water Trucks: 1, Southwest, 8000 (gall)
number model/power capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 40

69 in July, 1974 one shift, five days (80 employees work six months, then to construction activies)

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ____, In Headquarters: ____

(C) Contract Labor: Average for 1973: ____, % of year worked ____%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Acme ____
Town Number

Sheridan ____
Town Number

Ranchester ____
Town Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ____%, State: ____%, Private: 100 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ____, State Permit: ____
(if any)

12. Disposition of Surface in July 1974: Estimated from Photography.

(A) Active Pit and "Active" Spoils: 360 acres
(including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: 593 acres
(includes 23 acres of miscellaneous)

(C) Revegetated (Seeded and for Growing): 530 acres (part of part B)

(D) "Orphan Spoils" and Open Water: 50 (orphan); 100 (ponded) acres

(E) Support Facilities, Transportation Routes: 190 acres

TOTAL Disturbed (A+B+D+E) = 1293 acres.

13. Average Analyses of Coal:

Name of Coal Seam Dietz #2, Moisture 23.3 %, Ash (wet) 6 %

Na_2O(Ash) 1.49 %, Sulfur (wet) .84 %, Btu (wet) 9300 per lb.

Name of Coal Seam Dietz #3, Moisture 19 %, Ash (wet) 4.4 %

Na_2O(Ash) 4.25 %, Sulfur (wet) .5 %, Btu (wet) 9700 per lb.

Name of Coal Seam Monarch, Moisture 21 %, Ash (wet) 5.8 %

Na_2O(ash) 3.4 %, Sulfur (wet) .6 %, Btu (wet) 9550 per lb.

Name of Coal Seam Average, Moisture 24%, Ash (wet) 5.3 %

Na_2O(ash) ____%, Sulfur (wet) 0.61 %, Btu (wet) 9300 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Considerable old underground mining in this area (see attachment); also, underground mine fire and subsidence north of the Tongue River (Northern half of section 15); old mining normally removed no more than 10 feet of coal leaving rest, as roof; water is pumped from workings especially portion in Section 15.

Blasting AN-FO & dynamite 9' spacing coal, 25' spacing overburden 0.3#/ton coal; 0.7#/yd^3 overburden

Pit width ≈ 600'

Rye is "Nurse Crop", wheat grasses.

Pit sump pumped to Goose Creek.

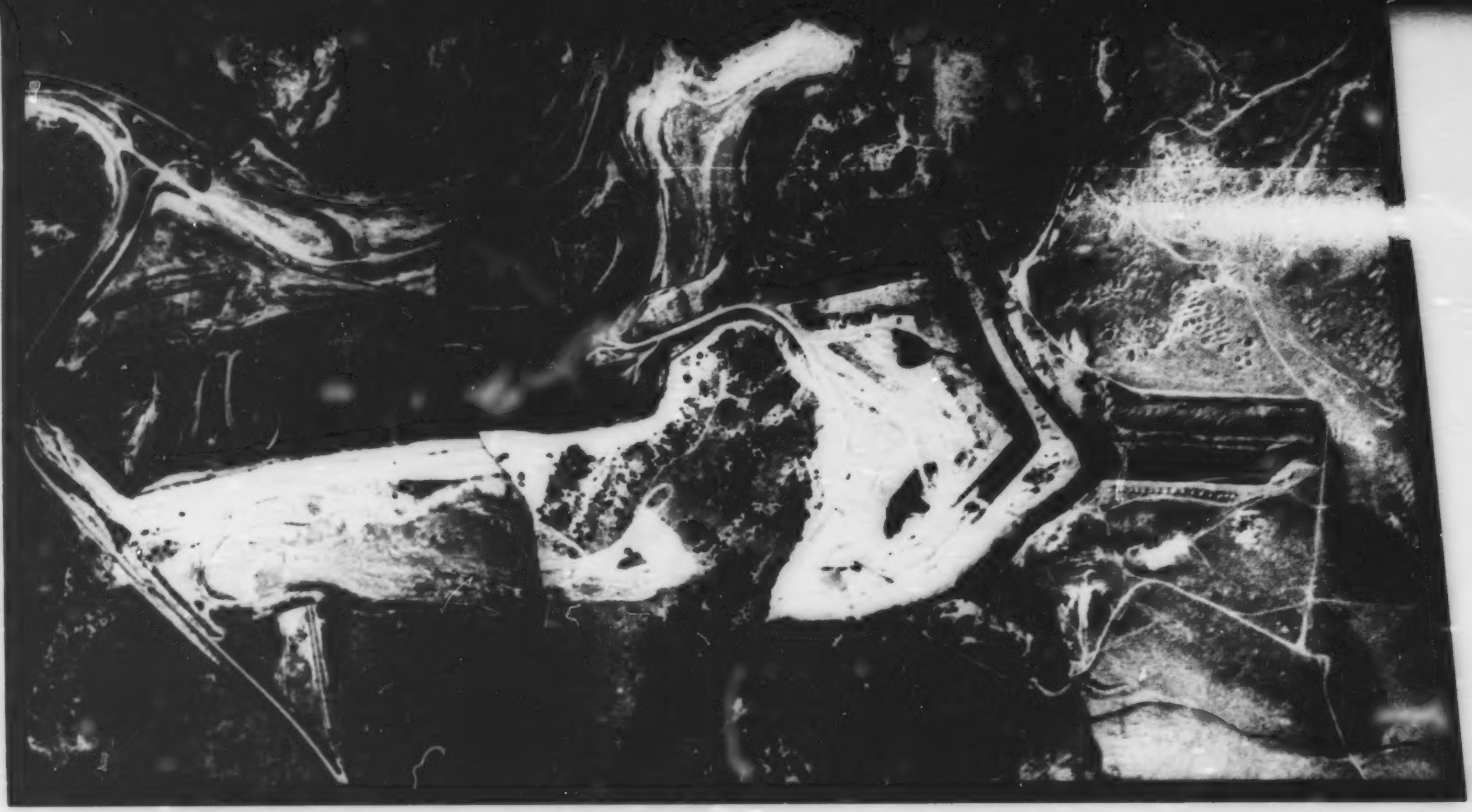
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PLATE 10

BIG HORN NO. 1 MINE
Big Horn Coal Company
Sheridan County, Wyoming
28Jul74 1440-1516 hrs

Photographs collected along south to north flight line. Horizon of photograph is west.

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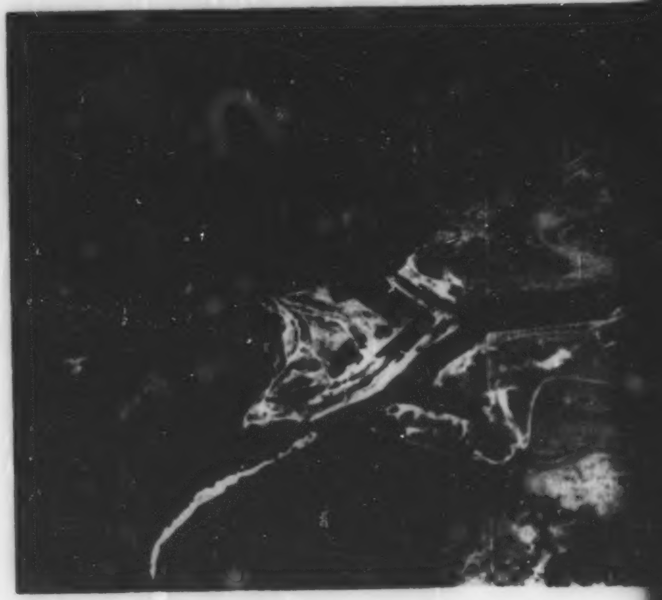
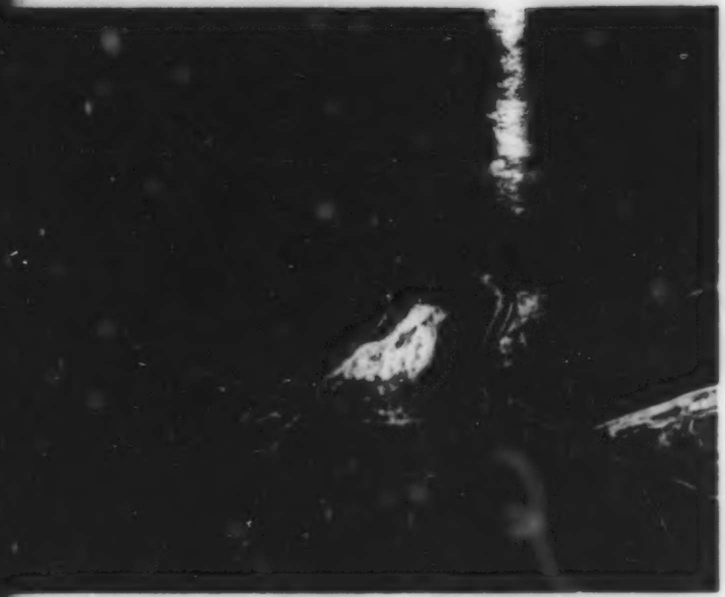
quence of phot





g south to north
tograph is west.

Continue to lower sequence of photographs.

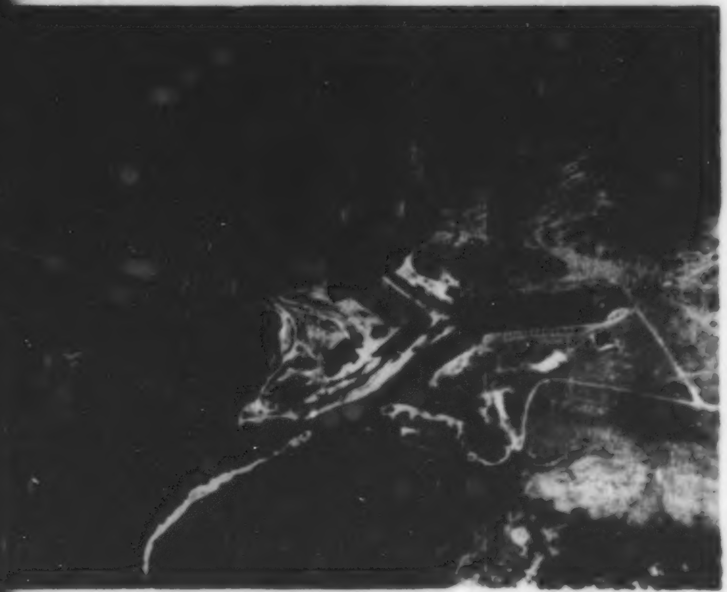


PLATE 11

BIG HORN NO. 1 MINE
Big Horn Coal Company
Sheridan County, Wyoming
28Jul74 1520 hrs Oblique

Section 5-7
Decker No. 1 Mine - Plates 12 and 13

Both true color and color infrared photography are provided for this mine. The true color was collected on 28 July 1974 from low altitude and is a mosaic. The color infrared was collected on 23 June 1975 from 17,300 meters (56,700 feet) and is a portion of a single frame. The large body of water to the east of the mine is the Tongue River Reservoir. A significant amount of infiltration enters the mine from that reservoir.

The thick coal bed (about 16 meters or 52 feet) has permitted mining at a rate approaching 6 to 7 million tons per year without much change in the mine plan from July 1974 to June of 1975. Reclamation activities are represented by the plot work centered on the test pit at the lower center of the photographs, and by the grading and emergence of seedlings shown at the north (upper) end of the pit beyond the mining operation. Spoils to the east of the exposed coal bed are not yet graded to any great degree since the mining plan also incorporates eastward mining of the same coal bed. The results of initial grading and re-seeding of the spoils are evident in the color infrared 1975 photography by the strip of magenta paralleling the pit in the west and north.

Drainage diversion ditches produce the white or brown paths along the western side of the mine. These lead drainage away from the mine into drainages not affected by the mine. The 1974 color mosaic shows the sedimentation pond at the extreme southeast corner of the mine. One can see coal haul trucks in the 1974 photography, but only the dragline is as clearly shown in the 1975 imagery.

The 1975 IR imagery vividly portrays strong vegetative growth in the valley of the Tongue River. Comparison of the two Plates shows the differences between a full (1975) and a drained (1974) reservoir.

Additional mining is planned for the east and northwest side of the reservoir.

DESCRIPTION OF MINE

1. Mine: Decker Number 1

2. Location: State: Montana County: Big Horn Township: 9S
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 40E Sec: 15,16

3. Mine Operators: Decker Coal Company ("Wytana, Inc.") Peter Kiewit and
Pacific Power & Light

4. Production Rates: For Year 1974: 4,159,287 tons per year
Estimated or Projected for Year 1974: 7,000,000 tpy
Monthly Average for 1974: ______ tons per month

5. Destination of Coal: (A) Estimated tons per year (______) to
Havanna, IL — Steam Electric
City, State — Use
(B) Commonwealth Edison Transfer to Barge

(B) Estimated tons per year (6 X 10^6) to
City, State — Use
Detroit Edison

(C) Estimated tons per year (1.25 X 10^6) to
City, State — Use

6. Description of Long-Haul Transportation (reference 5 above): via rail spur (19 miles) to Burlington Northern main line near Ucross, Wyoming.

(A) Unit Train (e.g., unit train), Ownership: Burlington Northern, # Cars 100 (W/slave unit) per train 13 to 21/week
Approximate rate of car loading ≈1.2 min. per car (100 ton)
Storage Capacity for loading 27,000 tons 2 silos, 700-ton truck bin, primary crushers to 8", secondary crushers to 2"

7. Stratigraphic Data:

(A) Average Overburden Thickness 70 feet; range ______ to 150 feet
O/B = Sandstone & Shale, Faulted on South by Burn Line

(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
Dietz #1 — 52

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
70-75 (20+30), ____, ____
Deeper Seams Dietz #2 15
thickness and approximate separation from mined seams.

(D) Depth of Active Pit: (feet) Average ______, Maximum: 150
Minimum: 30

(E) Bulking Factor for Spoils: ______ % (measured; estimated)

8. Major Operating Equipment:

Draglines: B-E 1300-W, 41 (cuyd), 285 (ft), 1750 (hp)
model, capacity, boom length, power rqmts

BE 1570, 71 (cuyd), under construction
model, capacity

Shovels: 2 ea BE 195B, 16 (cuyd), >49 (ft), 600/1500(hp)
model, capacity, max. radius (extended range), power rqmts

________, 16 (cuyd), ______ (ft), ______ (kw)
model, capacity, max.radius, power rqmts

Trucks: 9, Cat PW 660, 65-70 (tons)
number, model/power, capacity

1, Euclid, 120 (tons)
number, model/power, capacity

(150-ton WABCO on order)

Scrapers: 3, Cat 637, ______ (cuyd)
number, model/power, capacity

Dozers: 3, D-9, ______ (cuyd)
number, model/power, capacity

1, Cat 988, ______ (cuyd)
number, model/power, capacity

Drills: 1, B-E 60-R Overburden Drill, 480 hp
number, model/power, capacity

1, Gardner-Denver Coal Drill, ______ (cuyd)
number, model/power, capacity

Front End Loaders: 1, Dart, 23 (cuyd)
number, model/power, capacity

Water Trucks: ______, ______, ______ (cuyd)
number, model/power, capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 120

220 (180 mining) in July, 1974

Three shifts - seven days for dragline
Two shifts - six days for loading
One shift - five days for shooting

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ________, In Headquarters: ________

(C) Contract Labor: Average for 1973: ______, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

________________ ________
Town, Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ______%, State: ______%, Private: ______%

11. Coal Lease and "Permit" Numbers: (as of July 1974) Lease Area: 16,000 acres

Federal Lease: ______________, State Permit: ________________
(if any)

12. Disposition of Surface in 1975:

(A) Active Pit and "Active" Spoils: 680 acres
(including areas leveled for (Pit: 3100 acres)
dragline or shovel)

(B) Spoils Regraded or Being Regraded: 268 acres

(C) Revegetated (Seeded and for Growing): ________ acres

(D) "Orphan Spoils" and Open Water: ________ acres } 2185

(E) Support Facilities, Transportation Routes: ________ acres

13. Average Analyses of Coal:

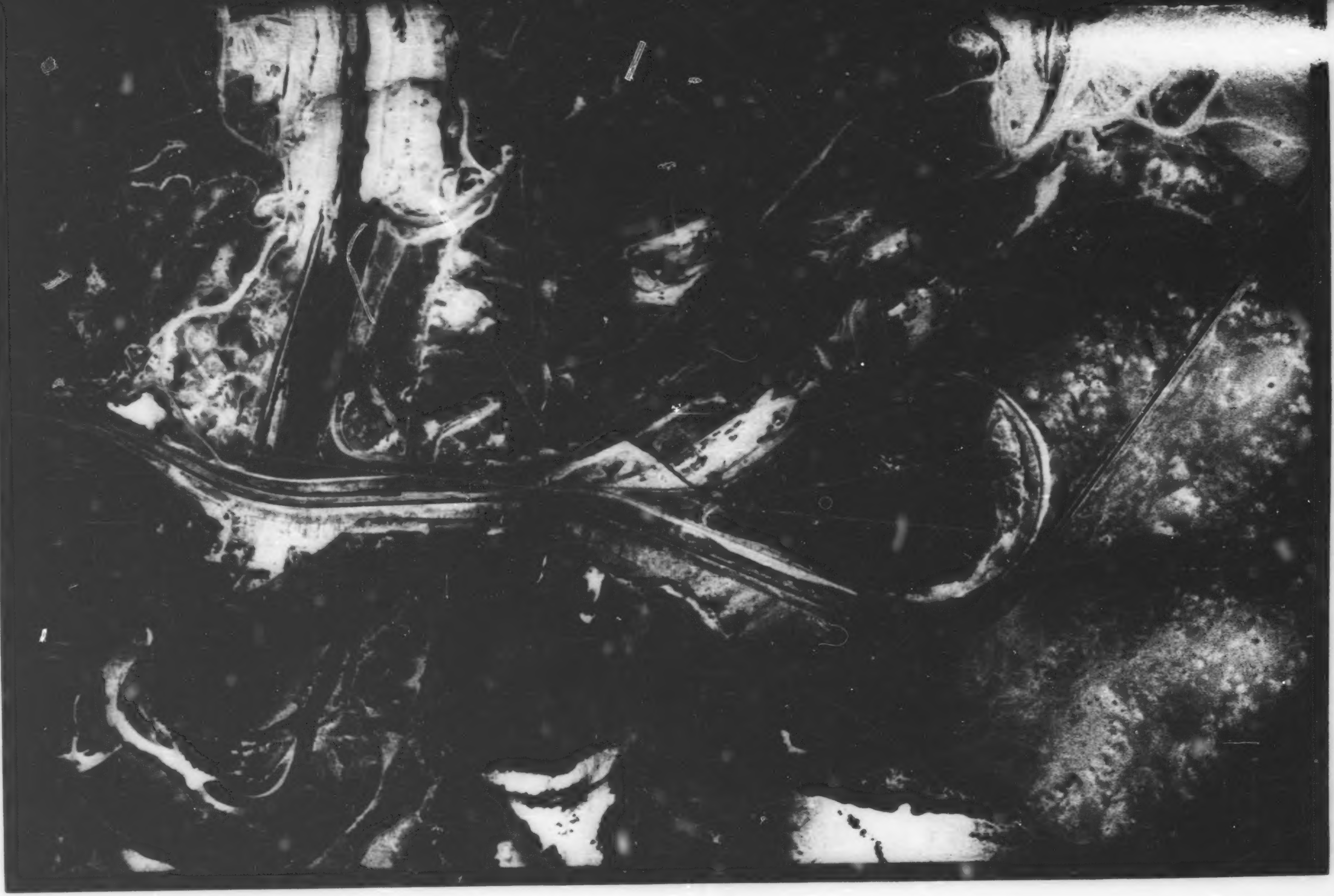
Name of Coal Seam Dietz #1, Moisture 23 %, Ash (wet) 3.7 %

Sulfur (wet) 0.4 %, Btu (wet) 9650 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Reserves Estimated at 1,000,000,000 tons.
Blasting AN-FO 15' spacing to 150' deep, overburden and coal - methane encountered in coal
coal shot in two benches.

Pit Width: 120-150'.
Coal mined in two benches.
Plan irrigation.
Research areas for Montana State; USDA-Forest Service.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0.25
0.5
MILES
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PLATE 12

DECKER NO. 1 MINE
(WEST DECKER)
Decker Coal Company
Big Horn County, Montana
28Jul74 1210-1227 hrs

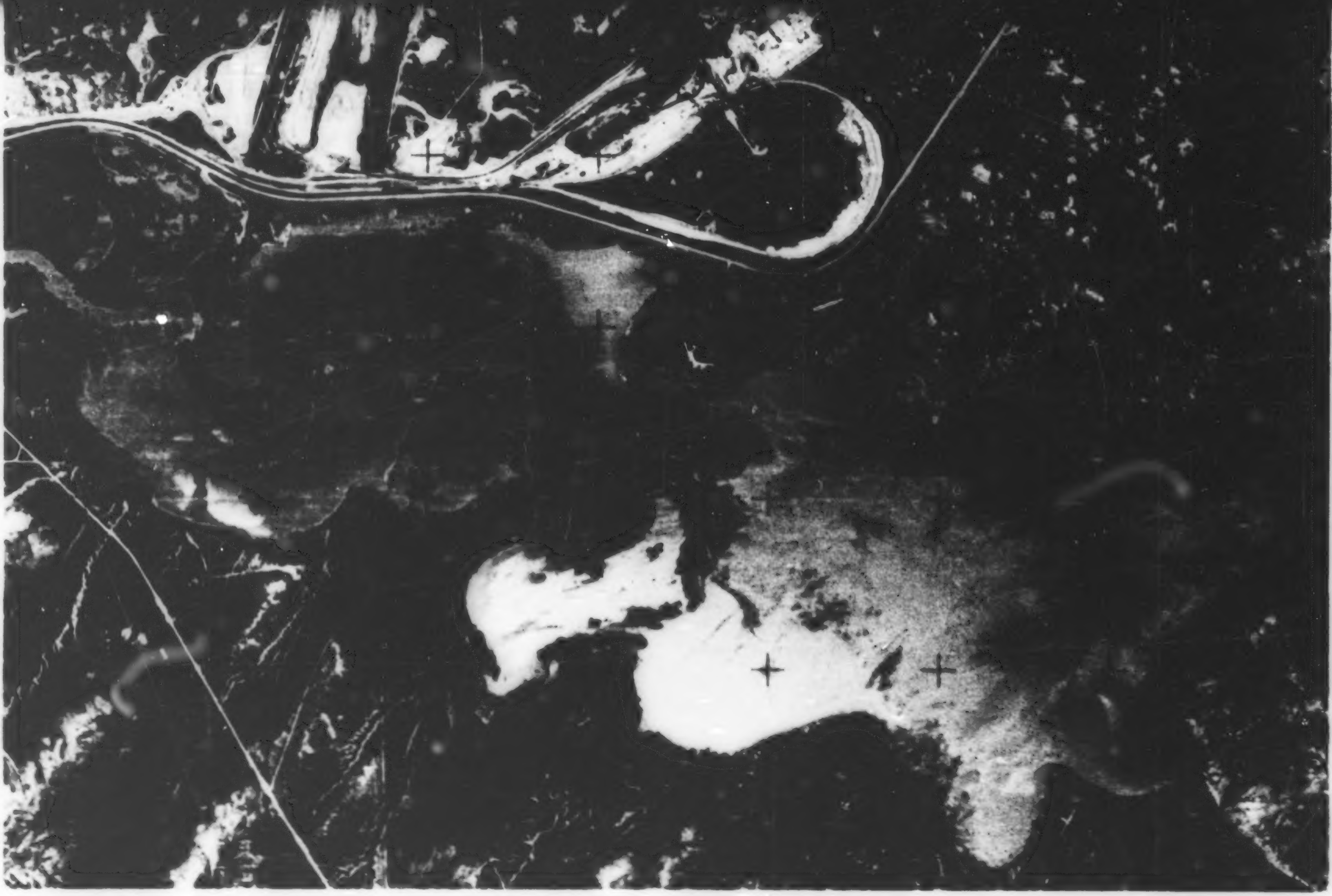

PLATE 13

DECKER NO. 1 MINE
(WEST DECKER)
Decker Coal Company
Big Horn County, Montana
23Jun75 Color IR High Alt.

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0.5
1
MILES
N

Section 5-8
Sarpy Creek (Absaloka) Mine - Plate 14

This mine is one of the newest in the Northern Great Plains. It is represented in this report by low-level aerial photography flown on 21 July 1974 presented in Plate 14 in true color. The area is characteristic of biological ecosystems at the moderate altitudes of eastern Montana as evidenced by the higher density of evergreen trees and shrubs.

The mine has more recently been called "Absaloka." It is located on Ceded lands adjacent to the Crow Indian Reservation.

A sediment pond dam is visible at the upper right (northwest) corner of the disturbed area, just east of the rail line embankment. Some grading had taken place at the time of this photograph. Those areas are located principally along the southwestern boundary of the mine. One seeded stockpile of topsoil is visible immediately south of the upper sedimentation pond.

The mine borders agricultural land on the east and northeast. Also visible is reddish baked shale at the southeast edge of the mine and along the northwestern side of the disturbed area.

DESCRIPTION OF MINE

1. Mine: Sarpy Creek (Absaloka)

2. Location: State: Montana County: Big Horn Township: 1N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 37E Sec: 23, 25, 26

3. Mine Operators: Westmoreland Coal Company - Morrison-Knudsen(Operators) - Kewanee Oil Company - Penn Virginia Corporation

4. Production Rates: For Year 1974: New tons per year
Estimated or Projected for Year 1974: 1,500,000 tpy
Monthly Average for 1974: ______ tons per month

5. Destination of Coal: (A) Estimated tons per year (______) to

______ Steam Electric
City, State Use
Northern States Pwr (Minn)
Interstate Pwr (Minn)
Dairyland Coop (Wis)
Wisconsin Pwr & Light

(B) Estimated tons per year (Total 4.048 X 10^6) to

Peroria, Ill (1 X 10^6 tpy) Steam Electric
City, State Use
Central Illinois Lghtg
Northern States Pwr (Minn. - Major)

6. Description of Long-Haul Transportation (reference 5 above): via 37-mile spur to Burlington Northern near Hysham, Montana.

(A) ______ (e.g., unit train), Ownership: Burlington Northern, # Cars 110 per train 11/wk

Approximate rate of car loading: ______ min. pr car (100 ton)

Storage Capacity for Loading ______ tons

7. Stratigraphic Data:

(A) Average Overburden Thickness 80 feet; range 20 to 200 feet

(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)

Stray #1	4'
Rosebud-McKay	30'
Stray #2	4'
Robinson	20'

Average total thickness - 58'

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)

30 , 8 , 60

Deeper Seams ______ ______ thickness and approximate separation from mined seams.

(D) Depth of Active Pit: (feet) Average 183, Maximum: ______

Minimum: ______

(E) Bulking Factor for Spoils: 30 % (measured; [✓ estimated])

8. Major Operating Equipment:

Draglines: Marion 8200-11R, 75 (cuyd), 325 (ft), ________ (kw)
model capacity boom length power rqmts

Shovels: ________, ________ (cuyd), ________ (ft), ________ (kw)
model capacity boom length power rqmts

Trucks: 4, Mack, 100 (115) tons
number model/power capacity
(Haul 3200' + 500' each year)

Scrapers: 4, Terex T24, ________ (cuyd)
number model/power capacity

Dozers: 3, D-9 Cat, ________ (cuyd)
number model/power capacity

1, C-8 Cat, ________ (cuyd)
number model/power capacity

Drills: 1, BE45R O/B Drill (11"), ________ (cuyd)
number model/power capacity

1, Gard-Den 16B Coal Drill (6"), ________ (cuyd)
number model/power capacity

Front End Loaders: 2, Michigan 475, 18 (cuyd)
number model/power capacity

Water Trucks: ________, ________, ________ (cuyd)
number model/power capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 70

________ in July, 1974 Two Shifts

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ________, In Headquarters: ________

(C) Contract Labor: Average for 1973: ________, % of year worked ____%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ________%, State: ________%, Private: ________% 100% Crow Indian

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ________, State Permit: ________ (if any)

Lease Area: 14,746 Acres

12. Disposition of Surface in January 1976:

(A) Active Pit and "Active" Spoils: ________ acres (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: ________ acres

} 157

(C) Revegetated (Seeded and for Growing): ________ acres
(D) "Orphan Spoils" and Open Water: ________ acres
(E) Support Facilities, Transportation Routes: ________ acres
} 187

13. Average Analyses of Coal:

Name of Coal Seam Rosebud-McKay, Moisture 23.75%, Ash (wet) 9.22 %
Sulfur (wet) 0.61 %, Btu (wet) 8573 per lb.

Name of Coal Seam Stray #2, Moisture 23.59%, Ash (wet) 12.84 %
Sulfur (wet) 1.53 %, Btu (wet) 8223 per lb.

Name of Coal Seam Robinson, Moisture 23.85%, Ash (wet) 7.79 %
Sulfur (wet) 0.52 %, Btu (wet) 8594 per lb.

Name of Coal Seam Average, Moisture 25 %, Ash (wet) 9 %
Sulfur (wet) 0.7 %, Btu (wet) 8450 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Reserves Estimated at 800,000,000 tons; 625,000,000 "minable" tons
Projected Production: 4 X 10^6 tpy 1975; 5 X 10^6 tpy 1976; 15 X 10^6 tpy ≈ 1988
Overburden Pattern: ≈ 30' X 30' ANFO used

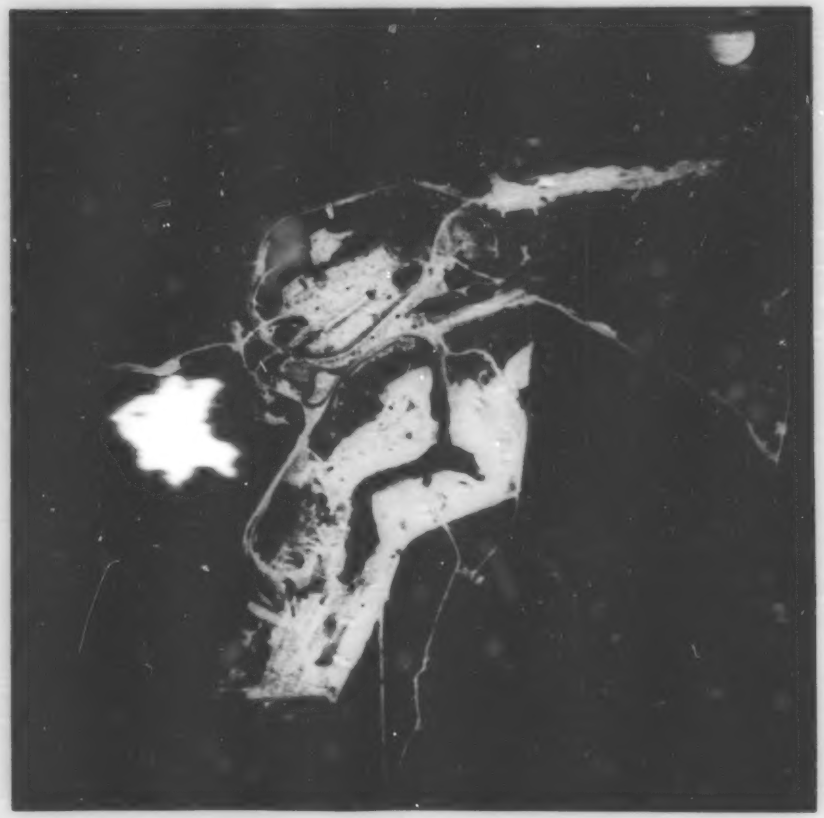


PLATE 14

ABSALOKA MINE
(SARPY CREEK)
Westmoreland Coal Company
Big Horn County, Montana
21Jul74 1130-1132 hrs

Section 5-9
Big Sky Mine - Plates 15 and 16

This mine was missed during the 1974 data gathering exercise and is therefore represented by color infrared imagery collected on 23 June 1975 from an altitude of 17,450 meters (57,300 feet) (Plate 16) and by color infrared imagery collected on 11 July 1975 from an altitude of 1,830 meters (6,000 feet) (Plate 15). The mine is relatively small in comparison to the nearby Rosebud Mine and is located south of Colstrip, Montana and west-southwest of the lower portion of the Rosebud Mine (See Section 5-10). The railroad loop is evident on the right-hand (east) side of the upper pit. The magenta tones of the color infrared photograph trace the principal drainages of the area while contrasting with the whites of the gravel roads and mined areas, and with the black of the exposed coal (along the left side of the upper pit) and coal in the coal preparation area. The color infrared imagery has not identified much vegetation growth over the disturbed areas except at the right bottom of the lower disturbed area in Plate 15 where some extremely vigorous vegetation is mixed in with more barren material. A portion of this is also represented in the 1975 photography of Plate 16. The light blue areas show accumulation of water. Greyish spoil and some less vigorous vegetative growth also appear across the disturbed areas.

This mine is located, as was the previously discussed one, in some evergreen areas representative of upland drainage areas.

DESCRIPTION OF MINE

1. Mine: Big Sky

2. Location: State: Montana County: Rosebud Township: IN
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 41E Sec: 13,14,15,22,23,26,27

3. Mine Operators: Peabody Coal Company

4. Production Rates: For Year 1974: 1,971,643 tons per year
Estimated or Projected for Year 1974: 2,700,000 tpy
Monthly Average for 1974: ____ tons per month

5. Destination of Coal: (A) Estimated tons per year (1,560,000) to
Cohasset & Aurora, Minn (City, State) Steam Electric (Use)
(Minnesota Pwr & Light)

6. Description of Long-Haul Transportation (reference 5 above):
(A) Unit Train (e.g., unit train), Ownership: Burlington Northern, # Cars 100 per train 3 trains per week
Approximate rate of car loading 1.2 min. per car (100 ton)
Storage Capacity for loading 25,000 tons

7. Stratigraphic Data:
(A) Average Overburden Thickness ____ feet; range 50 to 90 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)

Rosebud	26
McKay	10

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
8-35', shale
Deeper Seams ____ thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average ____, Maximum: ____
Minimum: ____
(E) Bulking Factor for Spoils: ____ % (measured; estimated)

8. Major Operating Equipment:
Draglines: Marion 7800 (model), 30 (capacity) (cuyd), ____ (boom length) (ft), North Pit
Marion 7400 (model), 14 (capacity) (cuyd), 175 (boom length) (ft), South Pit
Shovels: Marion 191 (model), 16 (capacity) (cuyd), ____ (max. radius) (ft), ____ (power rqmts) (kw)
Trucks: 4 (number), KW Dart (model/power), 120 (capacity) (tons)
(Changing to Euclid)
3 D-9 Cats
1 Ford 5000 Tractor

Scrapers: 1, WABCO, ________(cuyd)
number, model/power, capacity

Dozers: 2, Cat D-8, ________(cuyd)
number, model/power, capacity

Drills: 1, BE 50-R Overburden Drill 10 5/8", ________(cuyd)
number, model/power, capacity

1, BE 40-R Coal Drill 6", ________(cuyd)
number, model/power, capacity

Front End Loaders: ______, ________________, ________(cuyd)
number, model/power, capacity

Water Trucks: ______, ________________, ________(cuyd)
number, model/power, capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 25

________ in 1974

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ____________, In Headquarters: ____________

(C) Contract Labor: Average for 1973: ________, % of year worked ____%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

________________________ ____________
Town Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ________%, State: ________%, Private: ________%

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ____________, State Permit: ____________
(if any)

12. Disposition of Surface in 1974:

(A) Active Pit and "Active" Spoils: 226 acres (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: ________ acres

(C) Revegetated (Seeded and for Growing): ________ acres

(D) "Orphan Spoils" and Open Water: ________ acres

(E) Support Facilities, Transportation Routes: ________ acres

$\}$ 397

13. Average Analyses of Coal:

Name of Coal Seam Rosebud, Moisture 24.9 %, Ash (wet) 8.5 %

Sulfur (wet) 0.74 %, Btu (wet) 8600 per lb.

Name of Coal Seam McKay, Moisture ____%, Ash (wet) ______%

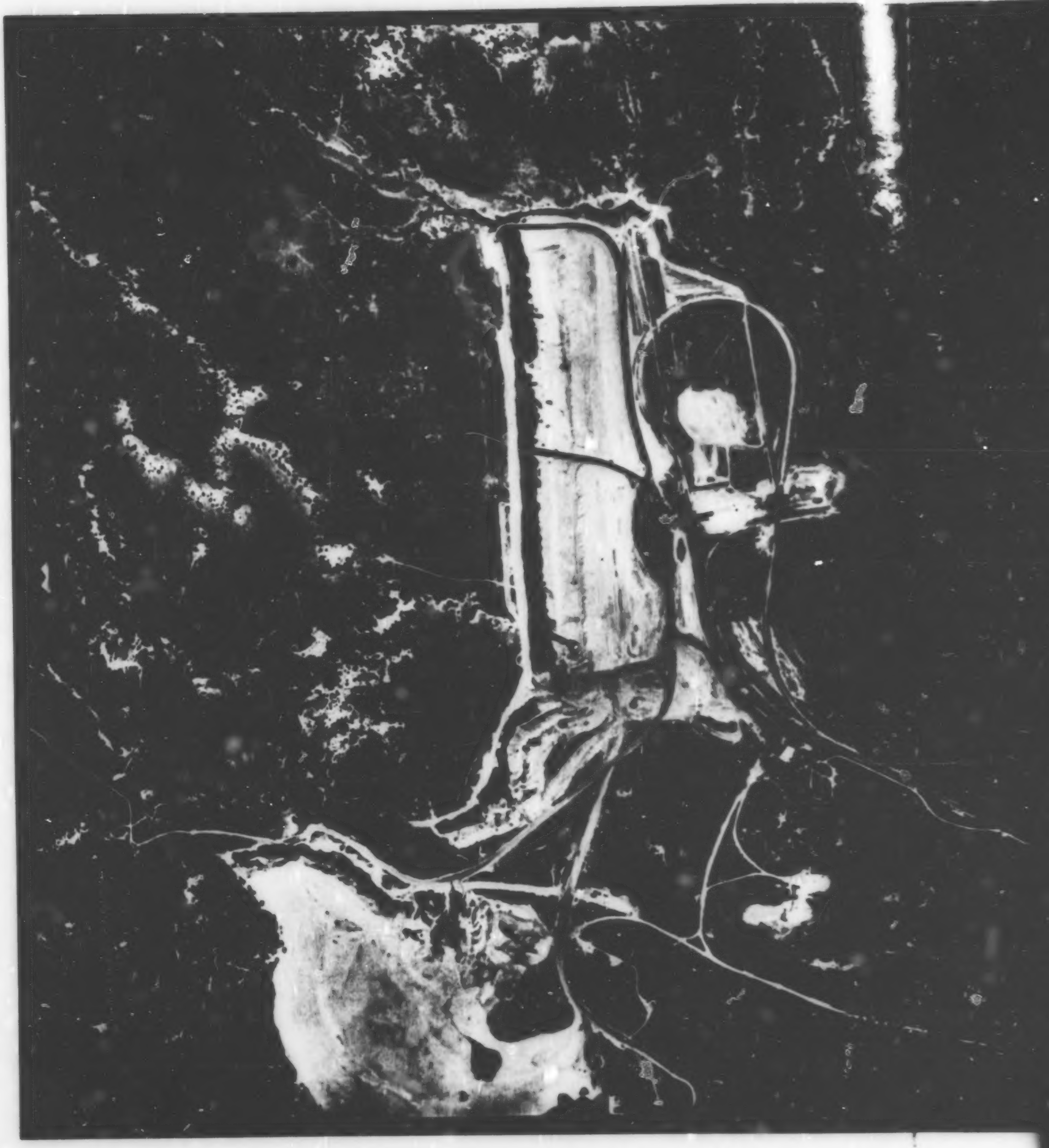
Sulfur (wet) _______%, Btu (wet) _______ per lb.

Name of Coal Seam Average, Moisture 20-25%, Ash (wet) 8.4 %

Sulfur (wet) 0.8 %, Btu (wet) 8750 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Blasting AN-FO 20-30' spacing.
Interburden shale is aquifer.



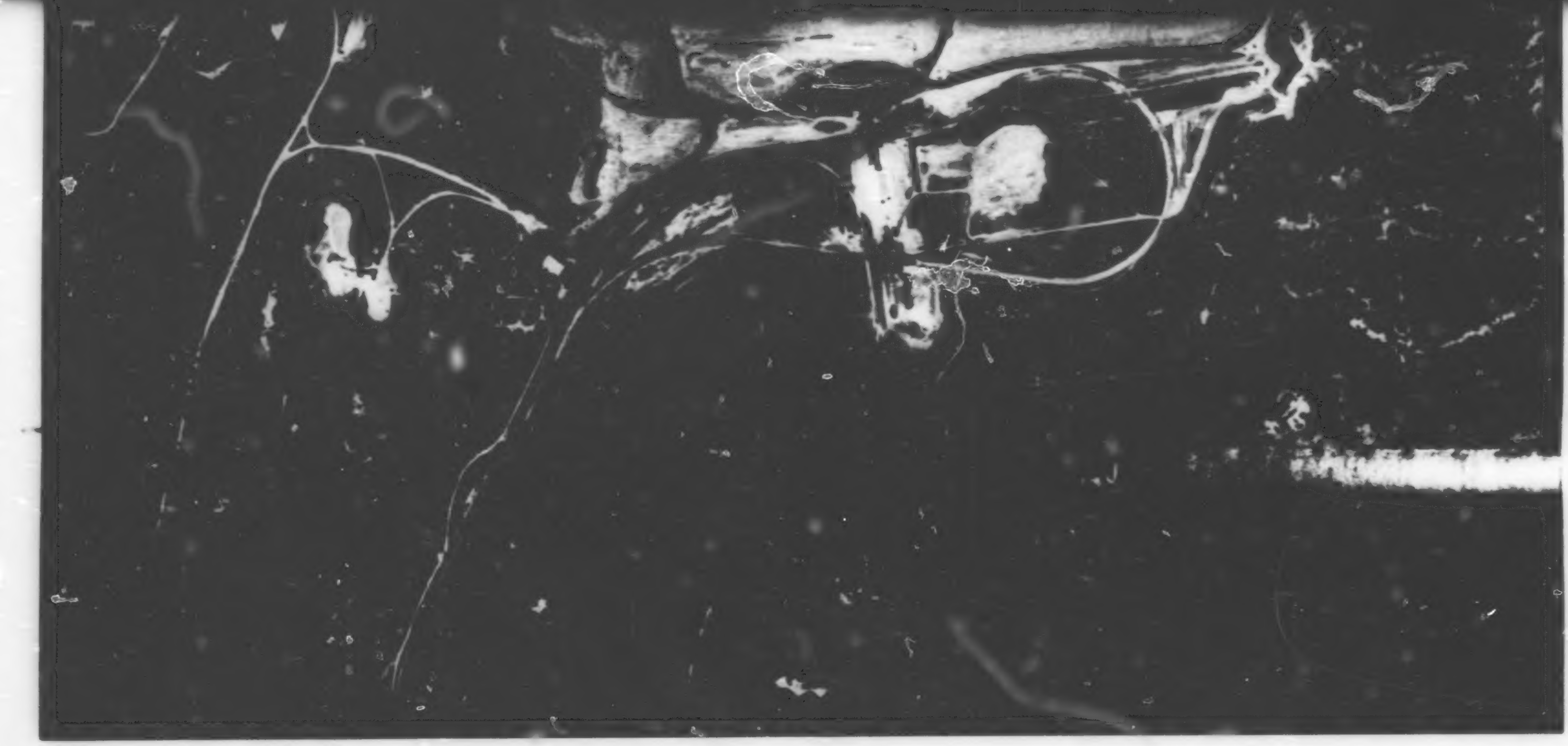


PLATE 15

BIG SKY MINE
Peabody Coal Company
Rosebud County, Montana
11Jul75

0
0.25
0.5
MILES
N

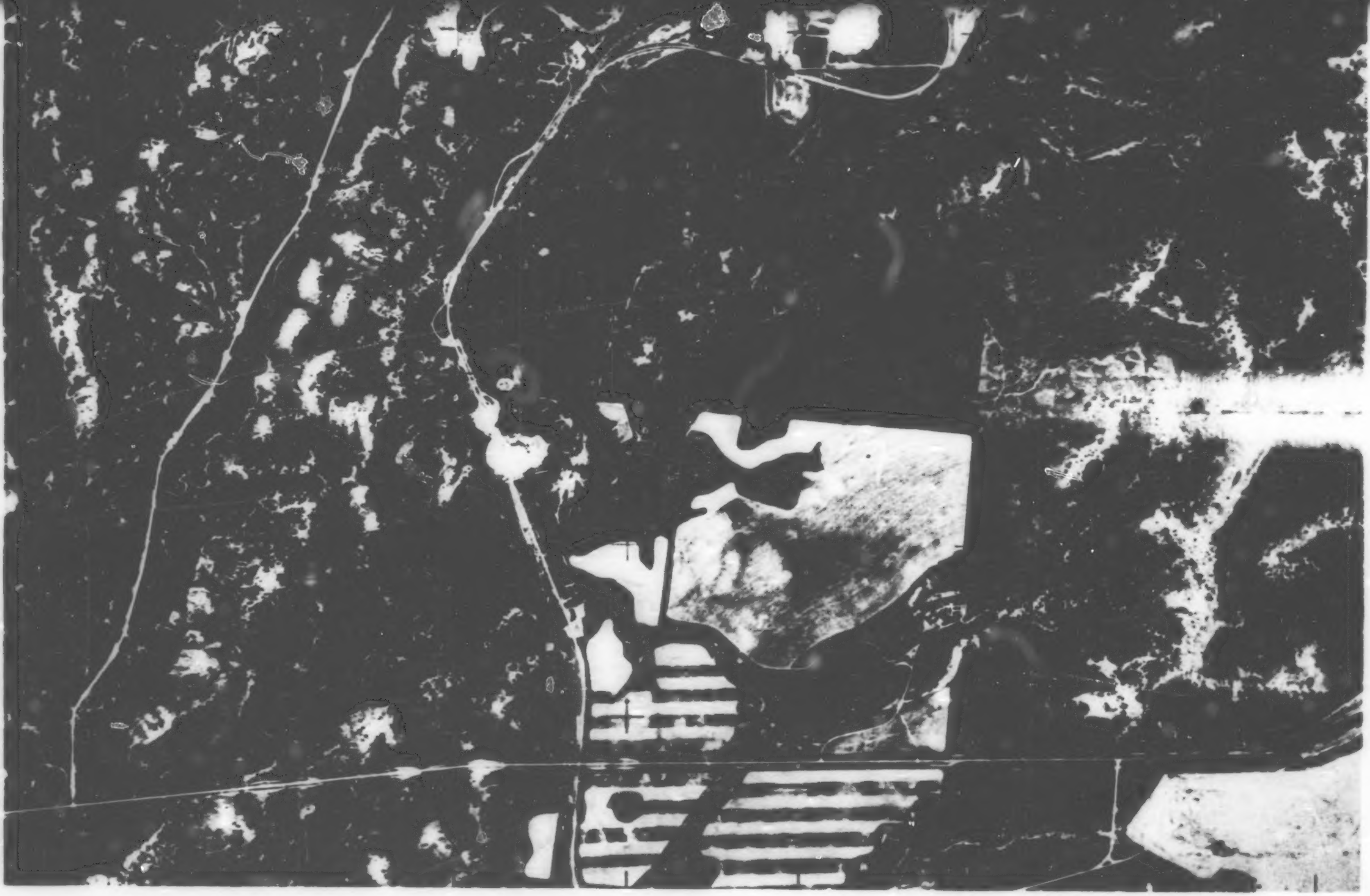


PLATE 16

BIG SKY MINE
Peabody Coal Company
Rosebud County, Montana
23Jun75 Color IR High Alt.

0
0.5
1
MILES
N

Section 5-10
Rosebud Mine - Plates 17, 18, and 19

This mine was photographed in July 1974 and again in June 1975. Imagery from the first flight, on 21 July 1974, is presented in true color (see Plate 17). The imagery for 23 June 1975 is color infrared. The true color is a mosaic of low altitude photography while the color infrared was obtained at an altitude of 17,450 meters (57,330 feet). We are afforded then the opportunity to again compare types of imagery and changes in time. Plate 19 provides an oblique view of the operation which includes the power plant, also collected on 28 July 1974.

Examination of the plowed fields show the alternating stubble and emerging June growth. Very healthy growth is evidenced in the irregular plots intersected by the roads by the green-brown and deep magenta hues. The southeast portion of the disturbed area (lower right) shows this quite well. The less vigorous growth immediately south of the coal train loading facilities is apparent in the June 1975 photography. Note also the completion of mining along the west edge of this same southern portion of the mine. The 1975 imagery shows the expansion of mining to the west, plus the additional construction associated with the town of Colstrip and the two units of the power plant (located just east of the town). Expanded trailer court facilities in Colstrip are also evident.

Vegetative growth at the bottom of the old Burlington Northern spoils is evidenced in both photographs (east of the town and plant site).

Most assuredly this site offers a full spectrum of examples of energy development activities. Note also the new activities being conducted in the creek valley to the west of Colstrip (Plate 18).

This mine is the site of numerous experimental activities regarding hydrology of spoils and revegetation.

DESCRIPTION OF MINE

1. Mine: Rosebud

2. Location: State: Montana County: Rosebud Township: 1N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 41E Sec: 1,2,11,12

3. Mine Operators: Western Energy Company - Montana Power (Long Construction Company Operators)

4. Production Rates: For Year 1974: 4,253,781 tons per year
Estimated or Projected for Year 1974: 2,837,000 tpy
Monthly Average for 1974: ______ tons per month

5. Destination of Coal: (A) Estimated tons per year (780,000) to
Billings, MT — Steam Electric
City, State — Use
(Montana Power & E., Corvette Sta)

(B) Estimated tons per year (1,456,000) to
St. Paul, Minn — Steam Electric
City, State — Use
(Northern States Pwr)

(C) Estimated tons per year (2,600,000) to
Chicago, Ill — Steam Electric
City, State — Use
(Commonwealth Edison)

(Total: 4,836,000)

6. Description of Long-Haul Transportation (reference 5 above): via 35-mile rail spur North to Burlington-Northern main line.

(A) Unit Train (e.g., unit train), Ownership: ______
______, # Cars 50 per train 3 trains per week

(B) Unit Train (e.g., unit train), Ownership: ______
______, # Cars 70 per train 4 trains per week

(C) Unit Train (e.g., unit train), Ownership: ______
______, # Cars 100 per train 3-7 trains per week

Approximate rate of car loading ______ min. per car (100 ton)

Storage Capacity for loading ______ tons

7. Stratigraphic Data:

(A) Average Overburden Thickness 90 feet; range 30 to 160 feet
Clay Sandstone, 30' in new pit

(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
Rosebud 27

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
____, ____, ____
Deeper Seams McKay
thickness and approximate separation from mined seams.

(D) Depth of Active Pit: (feet) Average ____________, Maximum: _________

Minimum: ______________

(E) Bulking Factor for Spoils: _________% (measured; estimated)

8. Major Operating Equipment:

Draglines: Marion 360, 60 (cuyd), ______ (ft), under construction
model, capacity, boom length

______, 8 (cuyd), ______ (ft), 700/1750 hp"old"
model, capacity, boom length, power rqmts

BE 1050-B, 24 (cuyd), 150 (ft), stripping
model, capacity, boom length

Shovels: BE 550-B, 17 (cuyd), ______ (ft), ______ (kw)
model, capacity, max. radius, power rqmts

BE 280-B, 17 (cuyd), 54 (ft), ______ (kw)
model, capacity, max. radius, power rqmts

Trucks: 3, ______, 100 (tons)
number, model/power, capacity

10, 100 HP Loco, 120 (tons)
number, model/power, capacity

Scrapers: 3, 631C, ______ (cuyd)
number, model/power, capacity

Dozers: 1, D84, ______ (cuyd)
number, model/power, capacity

2, D96, ______ (cuyd)
number, model/power, capacity

1, HD41, ______ (cuyd)
number, model/power, capacity

Drills: 1, BE45-R O/B Drill, 320 hp
number, model/power, capacity

1, CP 650 O/B Drill, ______ (cuyd)
number, model/power, capacity

1 overburden drill, 2 coal drills

Front End Loaders: 1, Hough 120-C, ______ (cuyd)
number, model/power, capacity

Water Trucks: ______, ______, ______ (cuyd)
number, model/power, capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 120

150 (80 mining) in July, 1974 Two shifts, five days

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ______________, In Headquarters: ________________

(C) Contract Labor: Average for 1973: __________, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town ____________________ Number ____________

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ________%, State: ________%, Private: ________%

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: 7,175 acres, State Permit: ____________ (if any)

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: ________ acres (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: ________ acres

(C) Revegetated (Seeded and for Growing): ________ acres

(D) "Orphan Spoils" and Open Water: ________ acres

(E) Support Facilities, Transportation Routes: ________ acres

13. Average Analyses of Coal:

Name of Coal Seam Rosebud, Moisture 24.3%, Ash (wet) 8.1 %
Sulfur (wet) 0.75 %, Btu (wet) 8628 per lb.

Name of Coal Seam Rosebud, Moisture 28 %, Ash (wet) 8.0 %
Sulfur (wet) 0.7 %, Btu (wet) 8750* per lb.
*Range 8600–9000

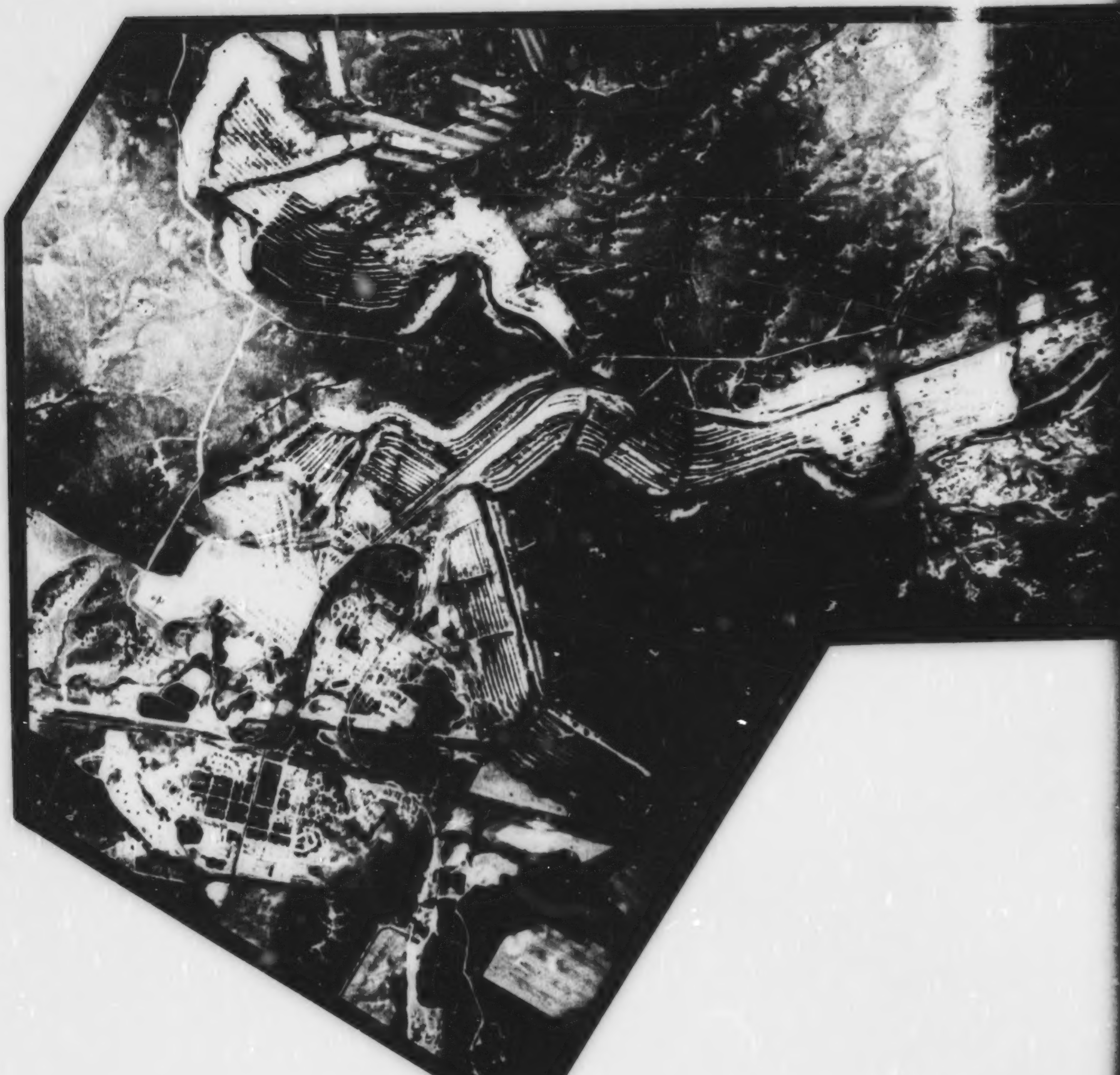
Name of Coal Seam McKay, Moisture 26.2 %, Ash (wet) 6.87 %
Sulfur (wet) 1.28 %, Btu (wet) 8514 per lb.

Name of Coal Seam McKay, Moisture 22 %, Ash (wet) 9.0 %
Sulfur (wet) 1.2 %, Btu (wet) 8300 per lb.

Name of Coal Seam Average, Moisture 25.5%, Ash (wet) 8.45 %
Sulfur (wet) 0.8 %, Btu (wet) 8800 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Reserves Estimated at 850,000,000 tons.
Blasting AN-FO & Dynamite coal and overburden.
Pit Width 120' to 160'.
First Year plant rye, oats; then replace with wheat grasses.
4" of coal left on floor as cushion over gray underclay; wedge 3' wide at base left to retain spoil.
Some revegetation efforts irrigated.
26" water pipeline front Yellowstone River.
Two 330 MW units under construction.
Annual precipitation 15".



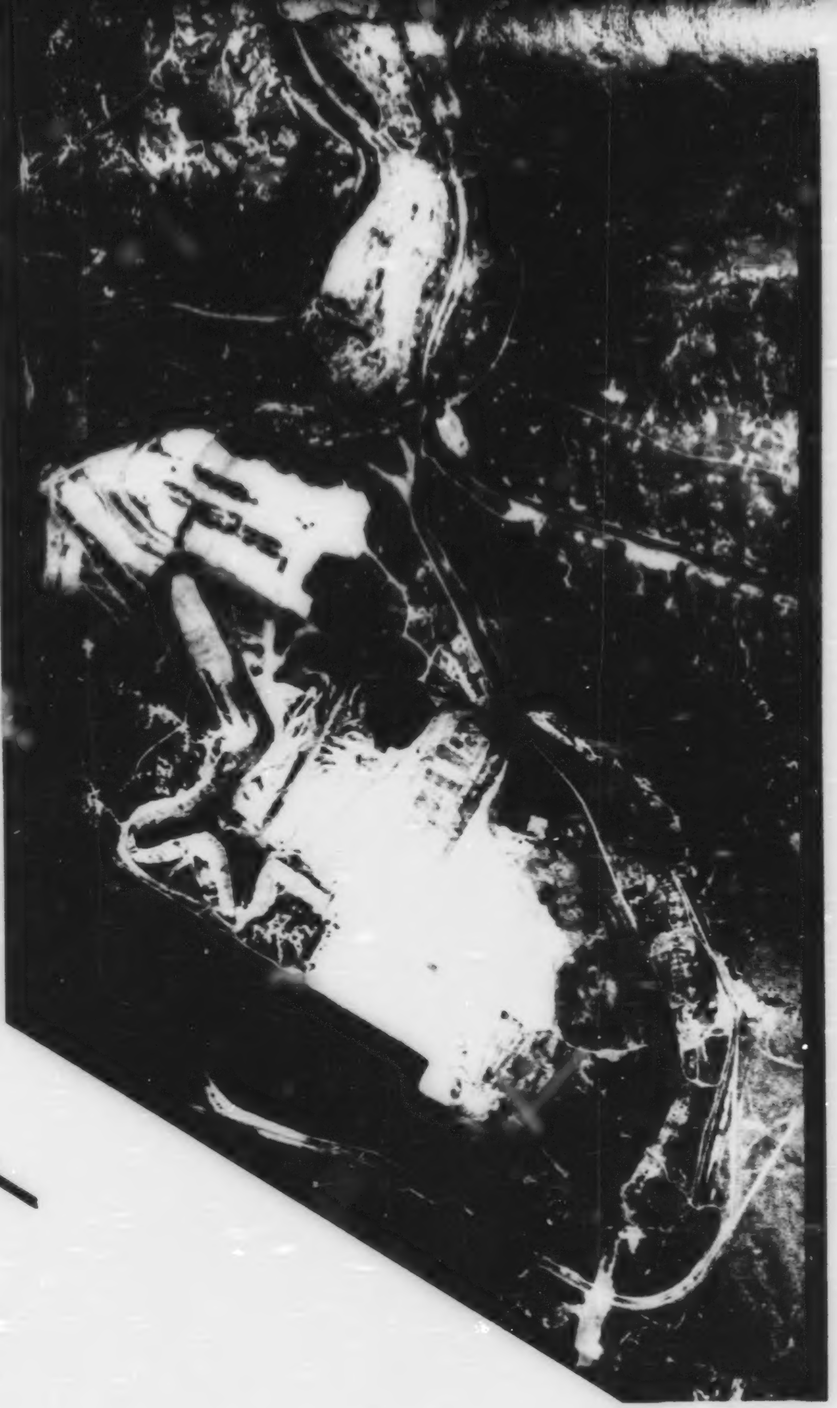
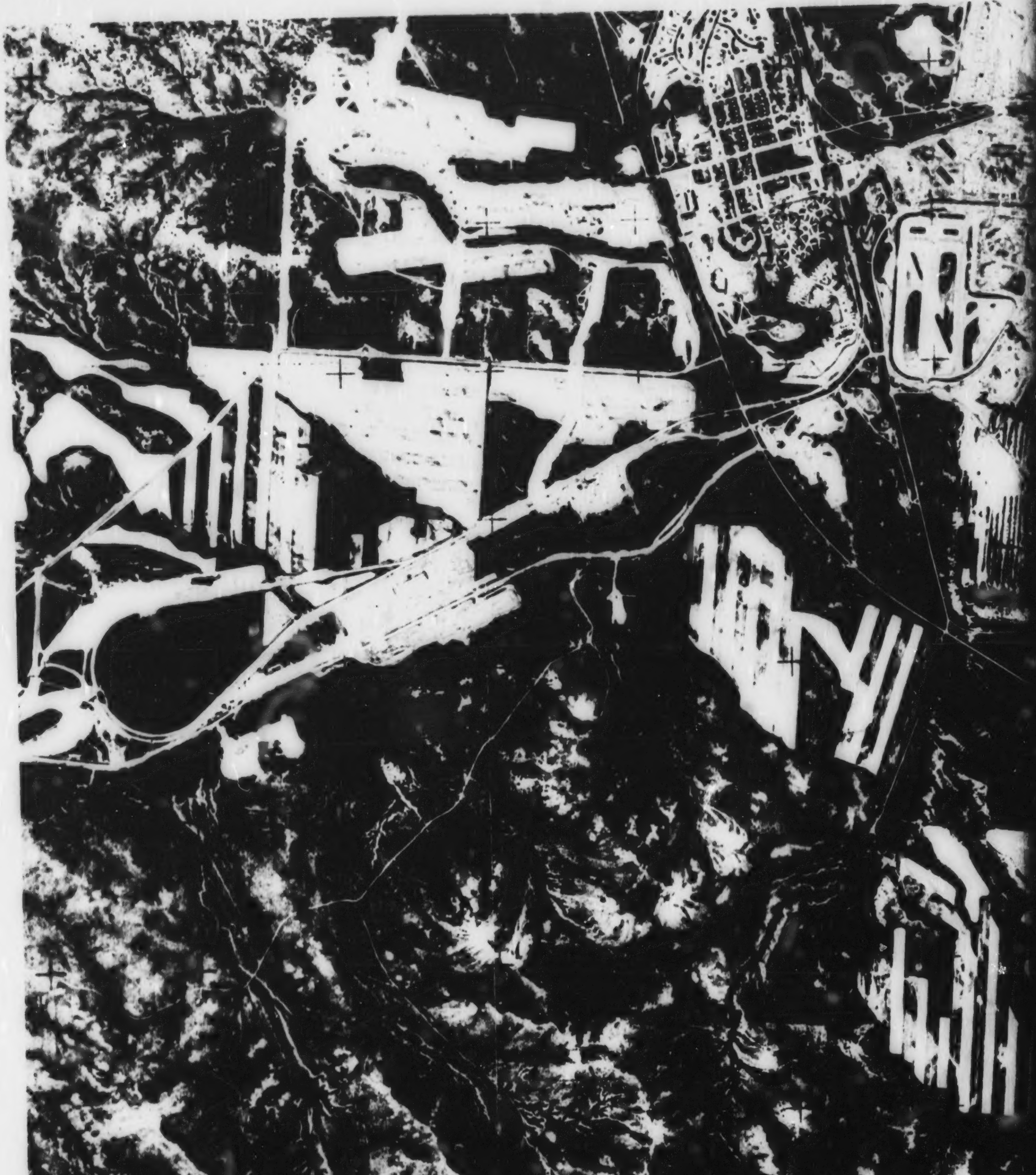
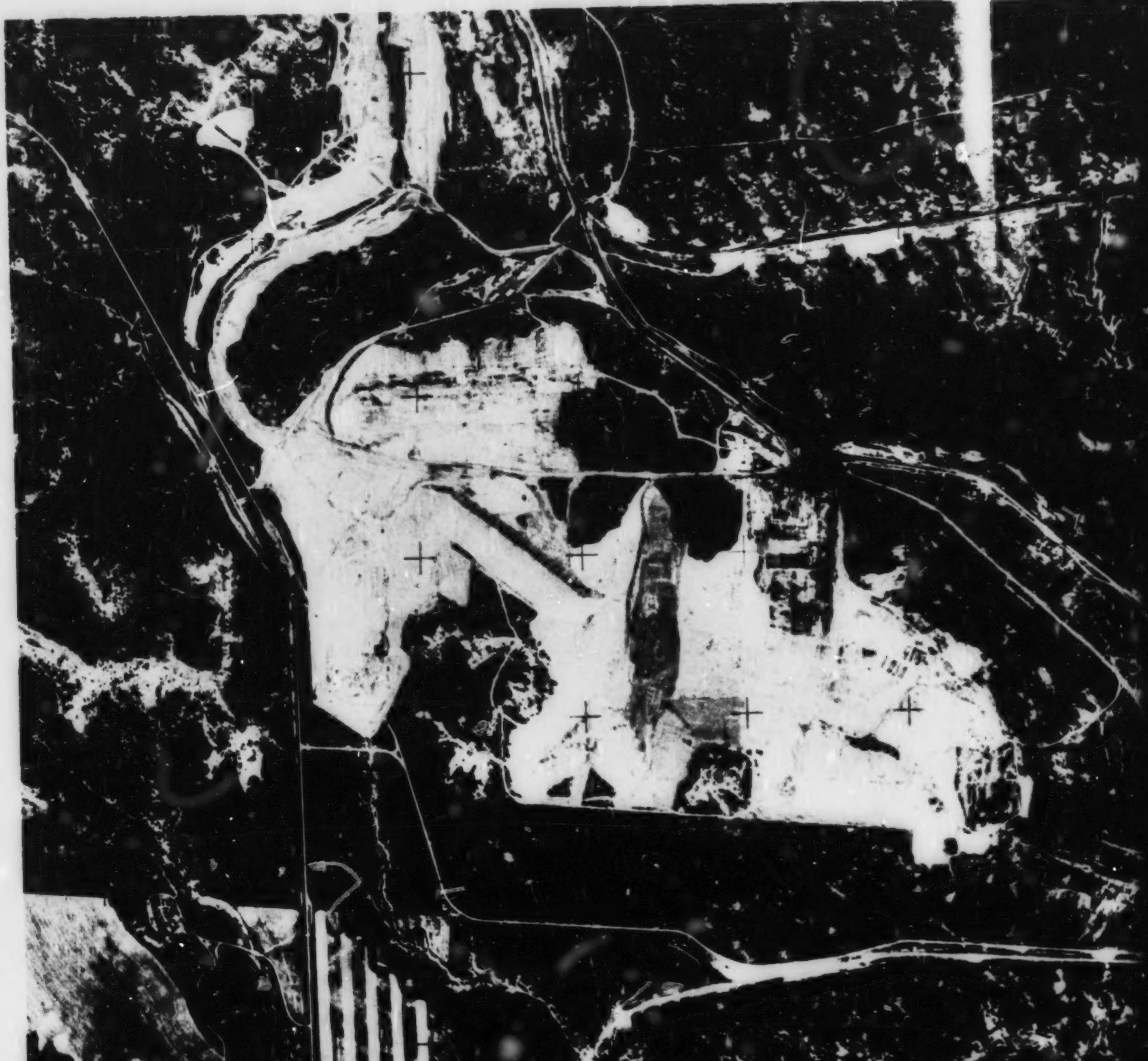

0
0.5
1
MILES
N

PLATE 17

ROSEBUD MINE
Western Energy Company
Rosebud County, Montana
21Jul74 1353-1453 hrs





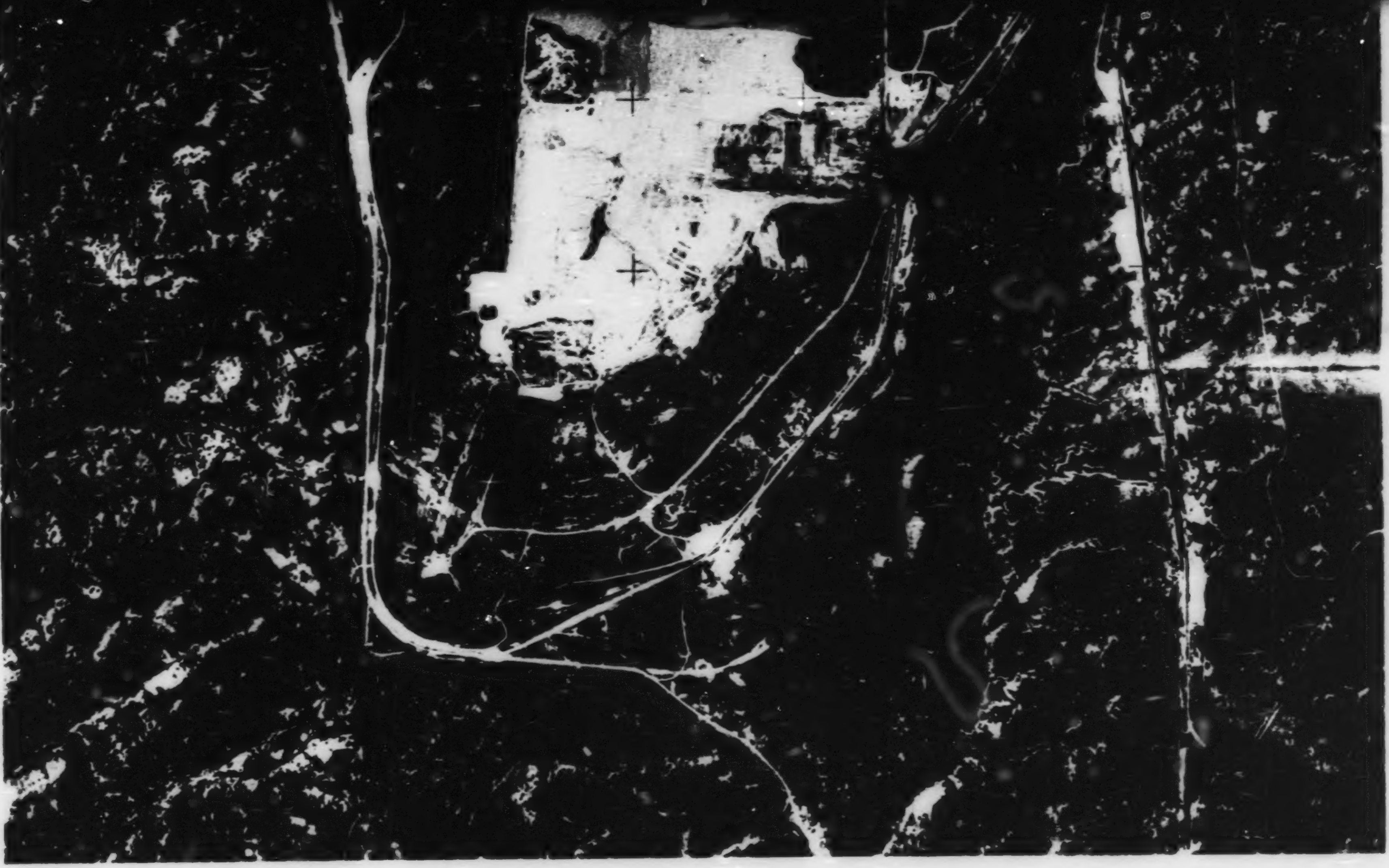
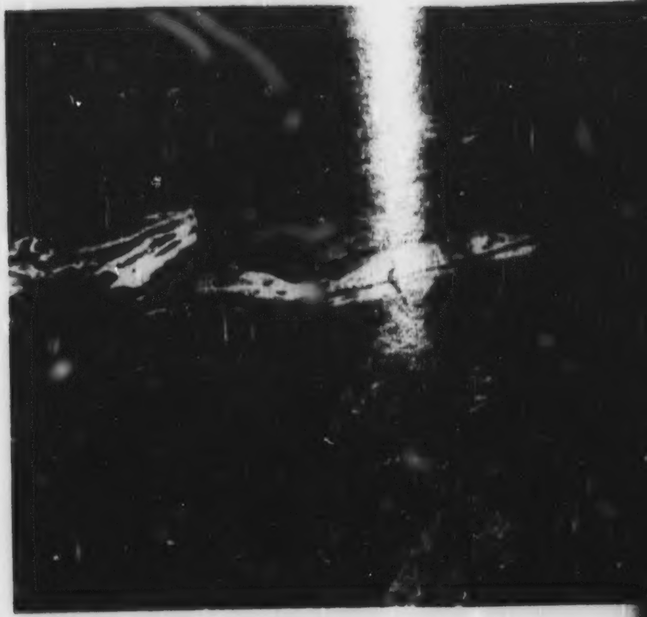


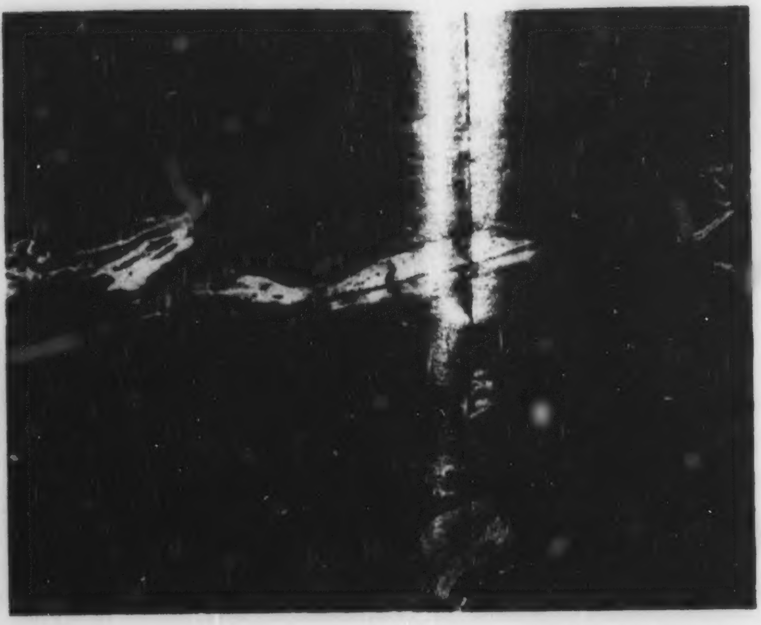
PLATE 18

ROSEBUD MINE
Western Energy Company
Rosebud County, Montana
23Jun75 Color IR High Alt.
(Two pages including preceeding page)



Continue
quence of

Photographs collected along south to north flight line. Horizon of photograph is west.



Continue to lower sequence of photographs.

along south to north
photograph is west.

PLATE 19

ROSEBUD MINE
Western Energy Company
Rosebud County, Montana
28Jul74 1520 hrs Oblique

Section 5-11

Savage Mine - Plates 20 and 21

This mine is represented by low altitude, true color photography mosaicked for Plate 20 as well as by two enlargements of the true color and of concurrently collected color infrared imagery presented in Plate 20. All information was collected on 22 July 1974.

The mine is a relatively small export operation and provides an example of grading and emergent vegetation over mined lands in agricultural areas. Mining is progressing westward. Grading has been accomplished over the southern pit. That southern area is again represented in the two enlargements of Plate 20. The magenta hues of the emergent vegetation in Plate 21b are noteworthy. The pit area to the north on Plate 20 also shows vegetative growth. A number of impoundments are visible. The false color (color infrared) print of Plate 21b defines the natural drainage channels and a rapidly greening area just southwest of the coal loading facilities which appears as a green area on Plate 21a.

New mining activity is apparent to the south of the older mined areas.

Some reclamation-related experiments are being carried out at this site.

DESCRIPTION OF MINE

1. Mine: Savage

2. Location: State: Montana County: Richland Township: 20N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 57E Sec: 22,27

3. Mine Operators: Knife River Coal Company

4. Production Rates: For Year 1974: 312,785 tons per year

Estimated or Projected for Year 1974: 320,000 tpy

Monthly Average for 1974: ______ tons per month

5. Destination of Coal: (A) Estimated tons per year (320,000) to

Sidney, MT — City, State

Steam Electric — Use
(50MW Lewis & Clark Station)

6. Description of Long-Haul Transportation (reference 5 above): Cecil Spur

(A) ______ (e.g., unit train), Ownership: Burlington Northern, # Cars ______ per train

Approximate rate of car loading: ______ min. per car

Storage capacity for loading ______ tons

7. Stratigraphic Data:

(A) Average Overburden Thickness ______ feet; range ______ to ______ feet

(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)

Pust — 9-20'

Total — 20'

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)

____, ____, ____

Deeper Seams ______ ______
thickness and approximate separation from mined seams.

(D) Depth of Active Pit: (feet) Average ______, Maximum: 90

Minimum: ______

(E) Bulking Factor for Spoils: ______% (measured; estimated)

8. Major Operating Equipment:

Draglines: 7W (model), 6 (capacity) (cuyd), ______ (boom length) (ft), ______ (power rqmts) (kw)

Shovels: P&H 655 (model), 3 (capacity) (cuyd), ______ (max. radius) (ft), ______ (power rqmts) (kw)

Trucks: 4 (number), ______ (model/power), 20 (capacity) (tons)

Scrapers: ______ (number), ______ (model/power), ______ (capacity) (cuyd)

Dozers: 1 (number), ______ (model/power), ______ (capacity) (cuyd)

Front End Loaders: 1 (number), ______ (model/power), ______ (capacity) (cuyd)

Water Trucks: ________ number, ________________ model/power, __________ capacity (cuyd)

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 18

__________ in July, 1974 one shift

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ____________, In Headquarters: ______________

(C) Contract Labor: Average for 1973: ________, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

________________________ Town ____________ Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ________%, State: ________%, Private: __________%

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ____________, State Permit: (if any) ______________

12. Disposition of Surface in 1976:

(A) Active Pit and "Active" Spoils: (including areas leveled for dragline or shovel) 170 acres

(B) Spoils Regraded or Being Regraded: ________ acres

(C) Revegetated (Seeded and for Growing): ________ acres

(D) "Orphan Spoils" and Open Water: ________ acres

(E) Support Facilities, Transportation Routes: ________ acres

$\}$ 152

13. Average Analyses of Coal:

Name of Coal Seam Average, Moisture 38 %, Ash (wet) 7-7.5 %

Sulfur (wet) 0.5 %, Btu (wet) 6500 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

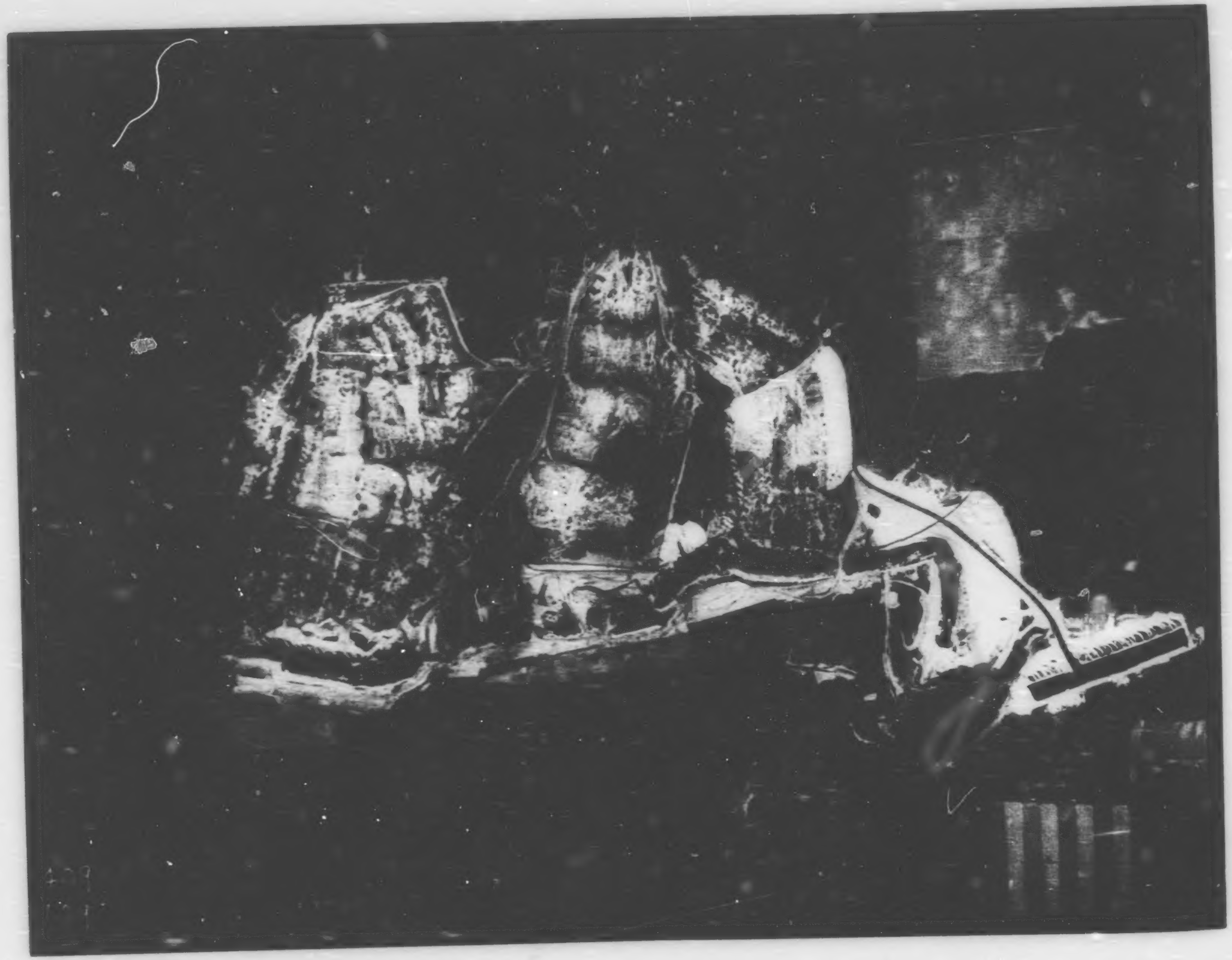


PLATE 20

SAVAGE MINE
Knife River Coal Company
Richland County, Montana
22Jul74 0946-0955 hrs

0
0.5
1
MILES
N

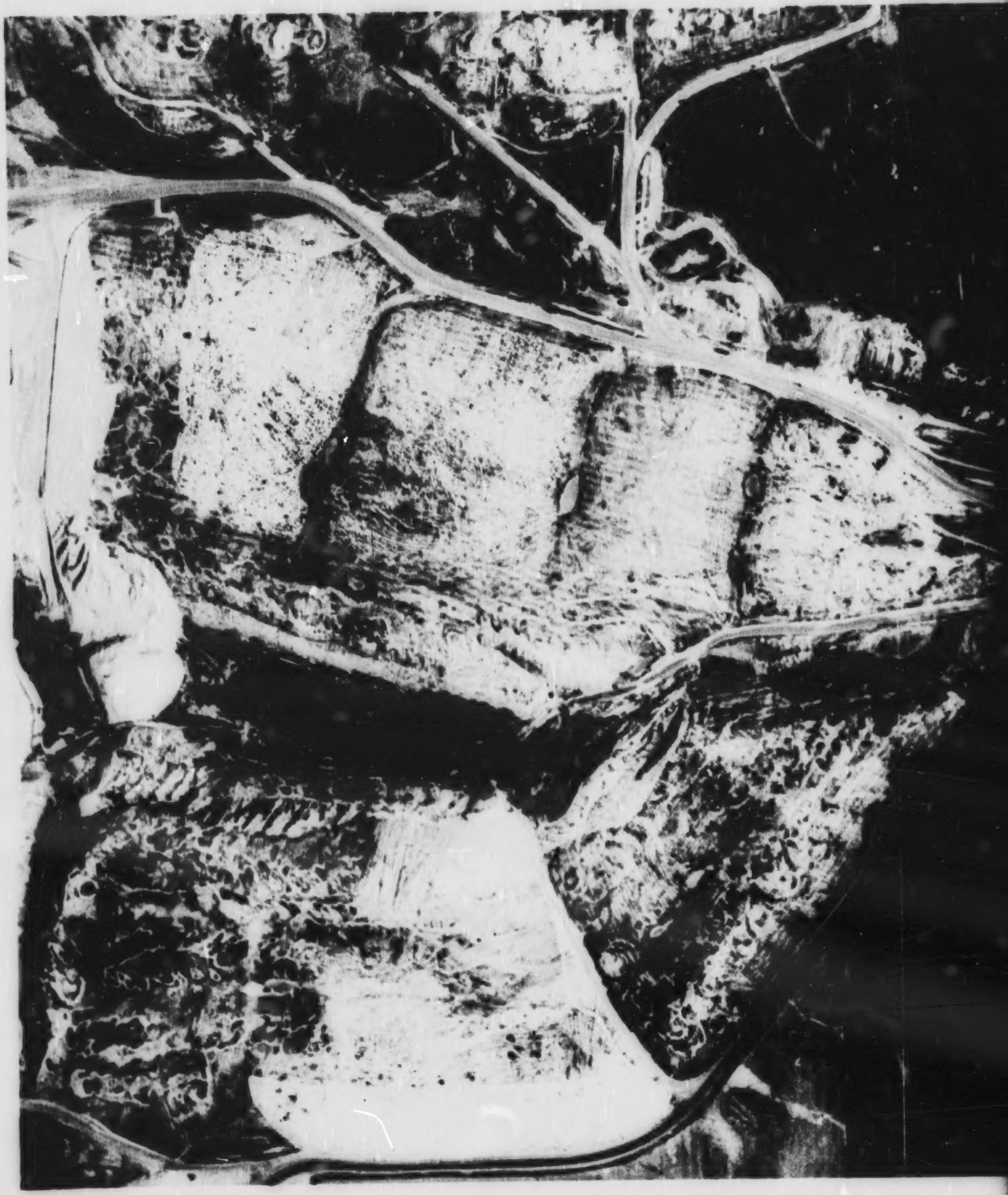


PLATE 21a

SAVAGE MINE
Knife River Coal Company
Richland County, Montana
22Jul74 True Color Low Alt.

0
500
1000
FEET
N

REVEGETATION EFFORTS

PLATE 21b

SAVAGE MINE
Knife River Coal Company
Richland County, Montana
22Jul74 Color IR Low Alt.

0
500
1000
MILES
N

Section 5-12
Peerless (Gascoyne) Mine - Plate 22

This mine is represented in true color photography flown on 23 July 1974. The mine has recently expanded and construction activities associated with that expansion are in evidence on the mosaic. The mine is, as are many North Dakota mines, located in farmed (cultivated) areas. Reclamation activity has increased and the graded spoils to the east as well as areas immediately north of the mine facilities show evidence of successful seeding and of invasion of volunteer growth.

Substantial water appears to be present in the open, non-working pits and the entire area presents the impression of a relatively shallow ground water table.

This mine is a site of a detailed hydrologic investigation of the effects of mining and reclamation.

DESCRIPTION OF MINE

1. Mine: Gascoyne (Peerless)

2. Location: State: North Dakota County: Bowman Township: 131N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 99W Sec: 32,33,34,35,27,28,29

3. Mine Operators: Knife River Coal Mining Company

4. Production Rates: For Year 1973: 185,011 tons per year
Estimated or Projected for Year 1974: 223,039 tpy
Monthly Average for 1974: 18,500 tons per month

5. Destination of Coal: (A) Estimated tons per year (114,000) to
Ortonville, MN — Otter Tail Power Co.
City, State — Use
(B) Estimated tons per year (29,000) to
Mobridge, SD — Montana-Dakota Utilities
City, State — Use
(C) Estimated tons per year (37,500) to
Gascoyne, ND — American Colloid Co.
City, State — Use

6. Description of Long-Haul Transportation (reference 5 above):
(A) Rail Road Cars (e.g., unit train), Ownership: Milwaukee Railroad, # Cars Varies per train
(B) Rail Road Cars (e.g., unit train), Ownership: Milwaukee Railroad, # Cars Varies per train
Approximate rate of car loading 30 min. per car (100 ton)
Storage capacity for loading None tons

7. Stratigraphic Data:
(A) Average Overburden Thickness 20 feet; range 10 to 30 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
Not Named 8,12,8
(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
6 , 6 , ____ Deeper Seams ____ ____ thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average 20 , Maximum: 30
Minimum: 10
(E) Bulking Factor for Spoils: 20 % (measured; [✓ estimated])

8. Major Operating Equipment:

Draglines:	7620 model	32 (cuyd), capacity	235 (ft), boom length	2500 hp Under construction power rqmts
	955 model	3 (cuyd), capacity	95 (ft), boom length	Diesel (kw) power rqmts
Shovels:	BE 195-B model	(cuyd), capacity	59 (ft), max. radius	600/1500 (kw) power rqmts
	51-B model	3 (cuyd), capacity	(ft), max. radius	Diesel (kw) pwr rqmts

Trucks:	4 number	DM-831SX model/power	20 (tons) capacity
Scrapers:	2 number	637 model/power	(cuyd) capacity
	1 number	MRS model/power	15 (cuyd) capacity
Dozers:	None number	model/power	(cuyd) capacity
Drills:	None number	model/power	(cuyd) capacity
Front End: Loaders	1 number	Hough model/power	(cuyd) capacity
Water Trucks:	1 number	B-835X model/power	(cuyd) capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 22

26 in July, 1974

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: None, In Headquarters: None

(C) Contract Labor: Average for 1973: ______, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number
Reeder	11
Scranton	10
Bowman	1

Not in named town: 3

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: 12.6 %, State: None %, Private: 87.4 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: 019127, State Permit: ________ (if any)

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: 35 acres (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: 140 acres

(C) Revegetated (Seeded and for Growing): 42 acres

(D) "Orphan Spoils" and Open Water: None acres

(E) Support Facilities, Transportation Routes: 65 acres

(F) "Inactive" : 39 acres

13. Average Analyses of Coal:

Name of Coal Seam 2nd, Moisture 41 %, Ash (wet) 7.6 %

Sodium (wet) 3.4%. Sulfur (wet) .75 %, Btu (wet) 6034 per lb.

Name of Coal Seam Average, Moisture 40 %, Ash (wet) 8 %

Sulfur (wet) 1-1.5 %, Btu (wet) 6100 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

During 1974, this mine was expanding - the actual mining operation had no contract labor. All contract labor was for expansion purposes.

0
0.5
1
MILES
N

PLATE 22

PEERLESS MINE
Knife River Coal Company
Bowman County, North Dakota
23Jul74 1158-1209 hrs

Section 5-13

Lehigh (Husky) Mine - Plate 23

This mine is represented by true color aerial photography collected on 23 July 1974. The mine is a relatively small one supplying a briquette and chemical plant. Reclamation has been and is taking place along south and east portions of the mine and grading is suggested at the northwest corner of the mosaic. The limit of seeding along the north appears to follow a fence line.

Note the subsidence features along the west side of the mine pit and plant caused by collapse of older underground drifts and haulage ways mined into the same coals now being mined from the surface.

DESCRIPTION OF MINE

1. Mine: Lehigh (Husky) Mine

2. Location: State: North Dakota County: Stark Township: 139N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 95W Sec: 7,8, 17

3. Mine Operators: Husky Industries

4. Production Rates: For Year 1974: 160,657 tons per year
Estimated or Projected for Year 1974: 160,000 tpy
Monthly Average for 1974: 13,300 tons per month

5. Destination of Coal: (A) Estimated tons per year (160,000) to
North Dakota (City, State) Husky Industries Inc. (Use)

6. Description of Long-Haul Transportation (reference 5 above): Not applicable. For own use.
(A) ________ (e.g., unit train), Ownership: ________
________, # Cars ____ per train
Approximate rate of car loading ____ min. per car (100 ton)
Storage Capacity for Loading ____ tons

7. Stratigraphic Data:
(A) Average Overburden Thickness 67 feet; range 50 to 75 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest
________ 9 feet
(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
____, ____, ____ Deeper Seams ________ thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average 67, Maximum: 75
Minimum: 50
(E) Bulking Factor for Spoils: ____% (measured; estimated)

8. Major Operating Equipment:
Draglines: Bucyrus (model), 6 (capacity) (cuyd), 100 (boom length) (ft), ____ (power rqmts) (kw)
Shovels: Bucyrus (model), 3 1/2 (capacity) (cuyd), ____ (mx. radius) (ft), ____ (power rqmts) (kw)
P&H (model), 2 (capacity) (cuyd), ____ (max. radius) (ft), ____ (power rqmts) (kw)
Trucks: 2 (number), 91FDB Euclid (model/power), 13 (capacity) (tons)
1 (number), LRUSW Mack (model/power), 26 (capacity) (tons)

	number	model/power	capacity	
Scrapers:	None			(cuyd)
Dozers:	None			(cuyd)
Drills:	None			(cuyd)
Front End: Loaders	None			(cuyd)
Water Trucks:	1	International		(cuyd)

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 8

8 in 1974

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ________, In Headquarters: ________

(C) Contract Labor: Average for 1973: 5, % of year worked 75 %

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number
Dickinson	8

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ________%, State: ________%, Private: 100 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ________, State Permit: #20
(if any) (Expires 1/1/76) (14 acres)

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: 16 acres
(including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: 11 acres

(C) Revegetated (Seeded and for Growing): 18 acres

(D) "Orphan Spoils" and Open Water: ----- acres

(E) Support Facilities, Transportation Routes: 5 acres

(F) "Inactive": 37 acres

13. Average Analyses of Coal:

Name of Coal Seam ________, Moisture 32 %, Ash (wet) 7 %

Sulfur (wet) 1 %, Btu (wet) 6400 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Underground mining PRE 1948.
No water-bearing strata encountered.

PLATE 23

LEHIGH STRIP MINE
(HUSKY NO. 2)
Husky Industries
Stark County, North Dakota
23Jul74 1300-1301 hrs

0
0.5
1
MILES
N

Section 5-14
Center Mine - Plate 24

This mine is portrayed in a true color photography flown on 27 July 1974 and mosaicked. The mine provides coal to the Milton R. Young plant of Minnkota Power. The large lake is Nelson Lake, which provides cooling water for the plant.

A portion of the mine extends off to the left (west) of the mosaic. Older, ungraded spoils are evident along the south part of the mine while grading and seeding efforts are visible along the southeast (nearer the plant) and northern mined areas.

DESCRIPTION OF MINE

1. Mine: Center

2. Location: State: North Dakota (all acreage on which present corporate owners have conducted or are conducting operations)

County: Oliver Township: 142N
Range: 84W Sec: 23,24,25,35,36
County: Oliver Township: 142N
Range: 83W Sec: 31,30
County: Oliver Township: 141N
Range: 84W Sec: 1

3. Mine Operators: Baukol Noonan Inc.

4. Production Rates: For Year 1974: 1,563,446 tons per year
Estimated or Projected for Year 1974: 1,500,000 tpy
Monthly Average for 1974: 130,287 tons per month

5. Destination of Coal: (A) Estimated tons per year (1,563,446) to
Center, ND — City, State
EGS (Mine-Mouth oper) (Minnkota Power Co.) — Use

6. Description of Long-Haul Transportation (reference 5 above):
(A) (Short Haul) RR (e.g., unit train), Ownership: ________
________, # Cars ____ per train
(B) 120 ton coal haulers (e.g., truck), Ownership: Baukol Noonan
________, # Cars ____ per train
Approximate rate of car loading ____ min. per car (100 ton)
Storage capacity for loading ____ tons

7. Stratigraphic Data:
(A) Average Overburden Thickness 45 feet; range 30 to 75 feet (clay shale w/boulders)
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest) (Top seam has been encountered, a minimal amount of our production is from top seam.)
Hagel 11
(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
variable
____, ____, ____ Deeper Seams ________ ________ thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average ________, Maximum: ________
Minimum: ________
(E) Bulking Factor for Spoils: 25 % (measured; estimated)

8. Major Operating Equipment:

Draglines: Page, 21 (cuyd), 190 (ft), ______ (kw)
model capacity boom length power rqmts

Shovels: P&H 1500, 10 (cuyd), ______ (ft), ______ (kw)
model capacity max. radius pwr rqmts

Trucks: 4, KW Dart, 120 (tons)
number model/power capacity

Scrapers: 1, Cat 637, 30 (cuyd)
number model/power capacity

Dozers: 2, Graders, ______ (cuyd)
number model/power capacity

Drills: ______, ______, ______ (cuyd)
number model/power capacity

Front End Loaders: 1, Michigan 475, 14 (cuyd)
number model/power capacity

Water Trucks: 1, Caterpillar, ______ (cuyd)
number model/power capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 30

30 in July, 1974

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: 5, In Headquarters: ______

(C) Contract Labor: Average for 1973: None, % of year worked ____ %

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number
Center, ND	33
Hazen, ND	2

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: 0 %, State: 15 %, Private: 85 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ______, State Permit: 24 (375 acres)
(if any) Expires 1/1/77

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: ≈100 acres (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: ≈220 acres

(C) Revegetated (Seeded and for Growing): 205 acres

(D) "Orphan Spoils" and Open Water: None acres

(E) Support Facilities, Transportation Routes: 25 acres

(F) "Inactive": 507 acres

13. Average Analyses of Coal:

Name of Coal Seam Hagel, Moisture 36-40 %, Ash (wet) 8-11 %

Sodium 1 %, Sulfur (wet) 0.7 %, Btu (wet) 6200-6800 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Blasting - coal only 8-10' spacing.
Haul roads on 1500 to 1200 centers.
Pit width - 120'.
Ash is returned to pits and covered with >25' of overburden.
New MW unit under construction.
One area planted with grain rye; another treated with leonardite.

PLATE 24

CENTER MINE
Baukol Noonan Inc.
Oliver County, North Dakota
27Jul74 1533-1603 hrs

0
0.5
1
MILES
N

Section 5-15
Glenharold Mine - Plates 25 and 26

The Glenharold Mine, a mine of moderate size supplying a nearby power plant, is represented by low-level true color imagery collected on 27 July 1974. Color oblique photography collected at the same time is presented in Plate 25. The Missouri River is visible at the upper right corner of the mosaic as are two power plants. The unit on the right is supplied from this mine; the unit on the left is the United Power Association Stanton Plant and is supplied with coal from the Indian Head mine near Beulah, North Dakota, using unit trains (see Plate 27 in the Indian Head Mine).

The mine provides examples of many stages of reclamation. At the bottom right (southeast) little grading and only sparse vegetation is evident. Progressing northwestward across the mine, grading activities are more extensive. The area is dissected by natural drainages which have subsequently been interrupted by the rows of spoils. Test area revegetation efforts are represented by the darker green areas near the southwest corner of the mined area.

A more advanced (by virtue of relatively concurrent grading) mining sequence is shown in the northern part of the mine where the coal bed is shown exposed. Soil spreading on the light gray spoils is represented by the striated browner hues. Some vegetative growth is also evident in an area in the lower middle of the northern mined area.

This mine, as are the remainder of the North Dakota coal mines addressed here, lies in the glaciated region of North Dakota.

DESCRIPTION OF MINE

1. Mine: Glenharold

2. Location: State: North Dakota County: Oliver Township: 143N
(all acreage on which present corporate owners have conducted or are conducting operations)
Range: 84W Sec: 5, 6
County: Mercer Township: 144N
Range: 84N Sec: 3-5,8-10,13-15,18-20, 23,24,28-32

3. Mine Operators: Consolidation Coal Company

4. Production Rates: For Year 1974: 1,292,921 tons per year
Estimated or Projected for Year 1974: 1,300,000 tpy
Monthly Average for 1974: ____ tons per month

5. Destination of Coal: (A) Estimated tons per year (____) to
Stanton, North Dakota Steam Electric
City, State Use
(Basin Elec Corp)

6. Description of Long-Haul Transportation (reference 5 above):
(A) Truck (e.g., unit train), Ownership: ____
____, # Cars ____ per train
(B) Conveyor (e.g., unit train), Ownership: ____
____, # Cars ____ per train
(C) Rail (e.g., unit train), Ownership: Burlington
Northern, # Cars ____ per train
Approximate rate of car loading ____ min. per car (100 ton)
Storage Capacity for loading ____ tons

7. Stratigraphic Data:
(A) Average Overburden Thickness 50 feet; range ____ to 80 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
(Clay with mud-siltstone boulders)

Lignite #3	2
Lignite #2	4
Lignite #3	8

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
30-35, 7-25, ____
Deeper Seams ____ ____
thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average 80, Maximum: ____
Minimum: ____
(E) Bulking Factor for Spoils: ____ % (measured; estimated)

8. Major Operating Equipment:

Draglines: B-E 1250B model, 32 (cuyd), capacity, 200 (ft), boom length, 1450 hp (kw) power rqmts

(scheduled) model, 45 (cuyd), capacity, ___ (ft), boom length, ___ (kw) power rqmts

Shovels: Marion 181-M model, 17 (cuyd), capacity, ___ (ft), max. radius, ___ (kw) power rqmts

B-E 85B model, 5.5 (cuyd), capacity, ___ (ft), max. radius, ___ (kw) power rqmts

Trucks: 4 number, Euclid 24TDT model/power, 60 (tons) capacity

10 number, Cat DW 20 model/power, 45 (tons) capacity

1 number, Unit Rig model/power, 196 (tons) capacity

Scrapers: ___ number, ___ model/power, ___ (cuyd) capacity

Dozers: 1 number, HD-41 Tractor model/power, 524 hp (cuyd) capacity

2 number, D-9 Tractor model/power, ___ (cuyd) capacity

2 number, D-8 Tractor model/power, ___ (cuyd) capacity

Drills: 1 number, Paris Mfg. Company 2 1/4" model/power, Coal Drill (cuyd) capacity

Front End Loaders: 1 number, Cat 988 model/power, 6.5 (cuyd) capacity

Water Trucks: ___ number, ___ model/power, ___ (cuyd) capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 78

73 in July, 1974 1 shift

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: ___, In Headquarters: ___

(C) Contract Labor: Average for 1973: ___, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

___ Town ___ Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ___%, State: ___%, Private: ___%

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ________________, State Permit: #3-1/1/76, #19-1/1/76
(if any) #26-10/1/77, #28-11/19/77
#29-6/1/78

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: 1975 acres
(including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: _________ acres

(C) Revegetated (Seeded and for Growing): _________ acres

(D) "Orphan Spoils" and Open Water: _________ acres

(E) Support Facilities, Transportation Routes: _________ acres

13. Average Analyses of Coal:

Name of Coal Seam Average, Moisture 38 %, Ash (wet) 6.8 %

Sulfur (wet) 0.65 %, Btu (wet) 6950 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Blasting Coal only, AN-FO and dynamite, 10' spacing.
Pit width, 120' + 50' access on bench.
Two 220MW units under construction.
Located on South-sloping Missouri River flood plain.
Bucket-wheel excavator used initially.
Trees planted during 1973.

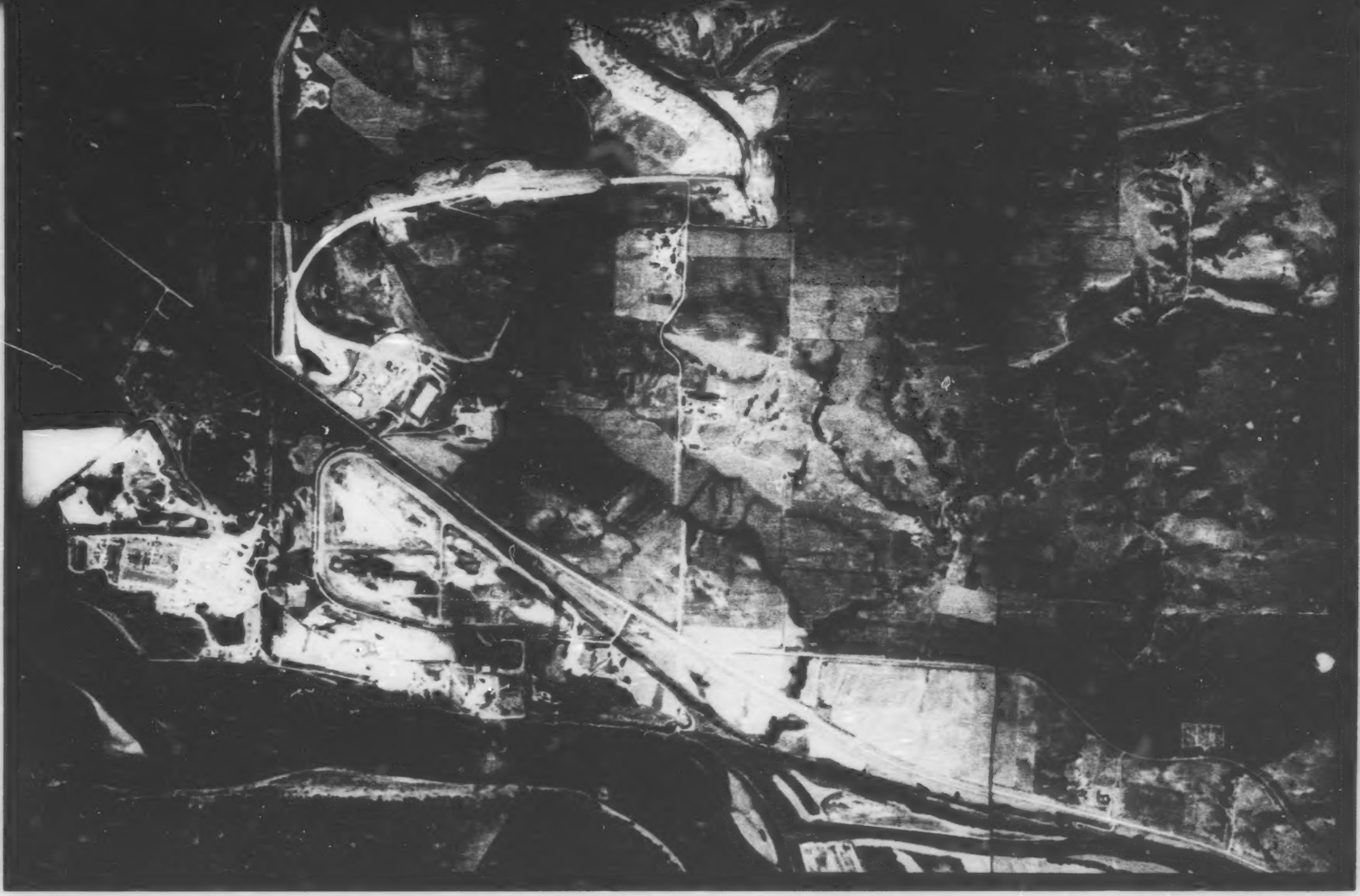
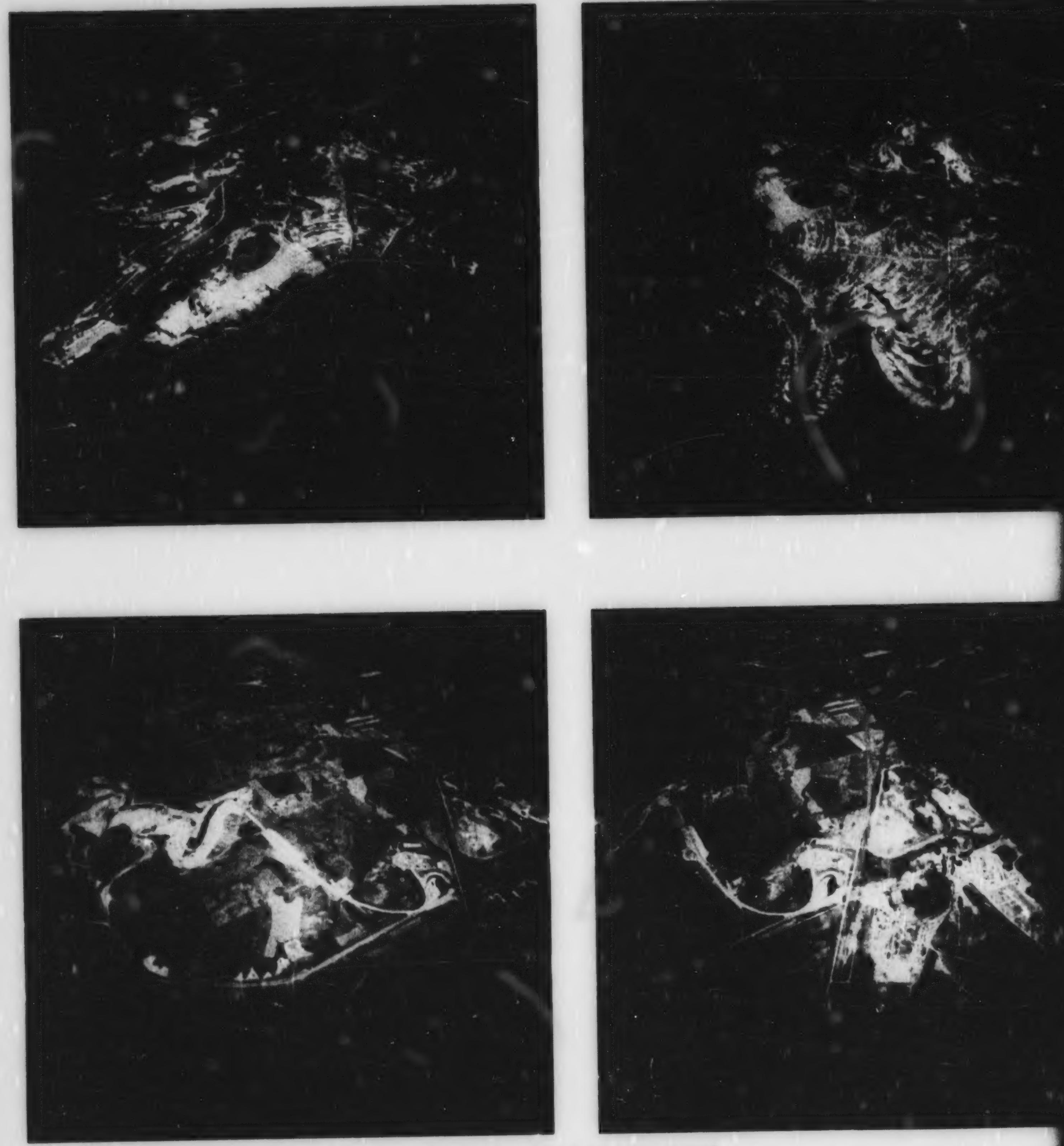
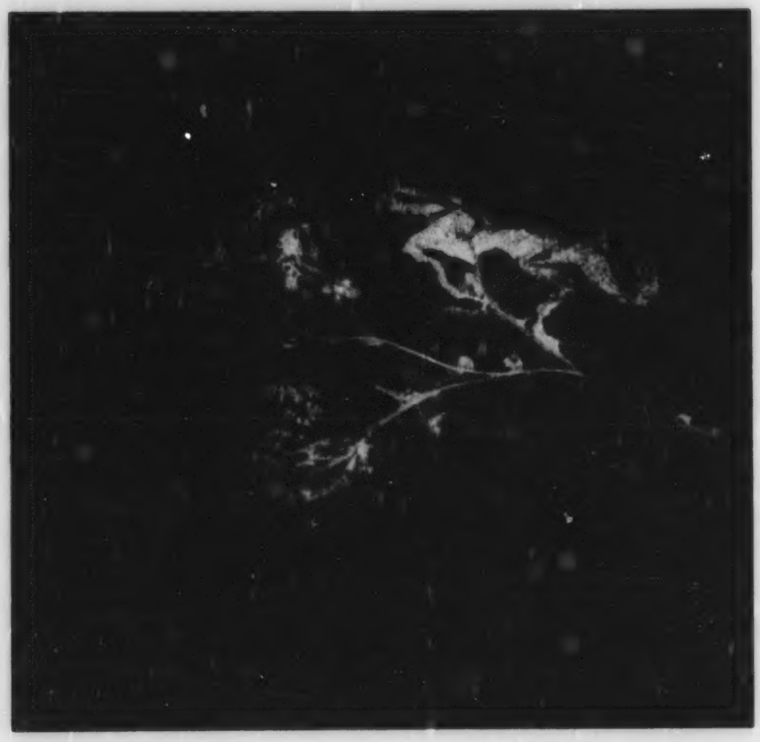


PLATE 25

GLENHAROLD MINE
Consolidation Coal Company
Oliver, Mercer Counties,
North Dakota
27Jul74 1135-1202 hrs



Photographs collected along south to north flight line. Horizon of photograph is west.



Continue to lower sequence of photographs.

PLATE 26

GLENHAROLD MINE
Consolidation Coal Company
Oliver and Mercer Counties,
North Dakota
27Jul74 1215 hrs Oblique

Section 5-16
Beulah (North and South) Mine - Plates 27 a & b

The southern portion of this mine is also represented by true color photography collected on 23 July 1974 at low altitude. Plate 27a, a mosaic, presents this imagery and shows a relatively regular mining pattern which is generally followed rather closely by grading and it would appear, "top-soiling". There are some signs of emerging vegetation on the graded and "top-soiled" areas along the south strip of the mine. A few areas along the edges of the mined strips are not graded.

The northern portion of this mine is represented on true color collected on 23 July 1974 at low altitude and mosaicked. Plate 27b presents not only the visible remnants of surface mining, at the left top (north) and right (east), but also, the perhaps more impressive remnants of underground mining of the shallow coals. Note throughout the area west of the Beulah North Mine, the regular pattern of depressions caused by subsdience into the drifts extending perpendicular from the main underground haulage ways. In the case of the subsidence shown in the north-central part of the mosaic, even the main haulage ways appear to have collapsed.

Extensive grading has been accomplished along the southern border of the northern mined area. Vegetative growth is also apparent there. Vegetative growth is similarly apparent on the north and east, (and northwest) facing spoil slopes. Trees and shrubs occur principally at the bottom of the spoil rows. Grading is also apparent in the northern section of this north mine but vegetative growth is not.

DESCRIPTION OF MINE

1. Mine: Beulah Mine North and South

2. Location: State: North Dakota County: Mercer Township: 143,144N
(all acreage on which present corporate owners have conducted or are conducting operations)
Range: 87, 88W Sec: 1, 2, 11, 12, 13, 14, 5, 8, 9, 16, 17
County: Oliver Township: 143
Range: 87 Sec: 6,7

3. Mine Operators: Knife River Coal Mining Company

4. Production Rates: For Year 1974: 1,726,349 tons per year
Estimated or Projected for Year 1974: 1,500,000 tpy
Monthly Average for 1974: 143,000 tons per month

5. Destination of Coal: (A) Estimated tons per year (750,000) to
Fergus Falls, MN Otter Tail Pwr Company
City, State Use
(B) Estimated tons per year (500,000) to
Mandan, ND Montana-Dakota Utilities Co.
City, State Use
(C) Estimated tons per year (250,000) to
Numerous small power plants
City, State Use

6. Description of Long-Haul Transportation (reference 5 above):
(A) Unit Train (e.g., unit train), Ownership: Burlington Northern, # Cars 60 per train
(B) Rail Road Cars (e.g., unit train), Ownership: Burlington Northern, # Cars 15 per train
(C) Rail Road Cars (e.g., unit train), Ownership: Burlington Northern, # Cars Varies per train
Approximate rate of car loading 6 min. per car (100 ton)
Storage capacity for loading none tons

7. Stratigraphic Data:
(A) Average Overburden Thickness 40 feet; range 10 to 90 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
Beulah-Zap bed 6', 12', 4'
(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
5 , ____ , ____
Deeper Seams ____ thickness and approximate separation from mined seams.

(D) Depth of Active Pit: (feet) Average 40, Maximum: 90

Minimum: 10

(E) Bulking Factor for Spoils: 20 % (measured; estimated)

8. Major Operating Equipment:

Draglines:	BE 480-W	16 (cuyd)	175 (ft)	1000 (kw)
	model	capacity	boom length	power rqmts
	BE 500-W	12 (cuyd)	195 (ft)	900 (kw)
	model	capacity	boom length	power rqmts
Shovels:	BE 110-B	8 (cuyd)	41 (ft)	250 elec (kw)
	model	capacity	max. radius	power rqmts
	P&H 1400	6 (cuyd)	(ft)	75 elec (kw)
	model	capacity	max. radius	power rqmts
	BE 71-B	3 (cuyd)	(ft)	250 (kw)
	model	capacity	max. radius	power rqmts

Trucks:	9	Euclid 35 Ldt	65 (tons)
	number	model/power	capacity
Scrapers:	2	637 Cat	30 (cuyd)
	number	model/power	capacity
	1	M-R-S I-80S	10 (cuyd)
	number	model/power	capacity
Dozers:	2	Dozers D-9	(cuyd)
	number	model/power	capacity
Drills:			(cuyd)
	number	model/power	capacity
Front End: Loaders	2	Hough	(cuyd)
	number	model/power	capacity
Water Trucks:			(cuyd)
	number	model/power	capacity

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 59

72 in July, 1974 Total two shifts

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: None, In Headquarters: None

(C) Contract Labor: Average for 1973: None, % of year worked ___ %

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Beulah	62
Town	Number
Out- of- Town	10
Town	Number

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

North
Federal: 12 %, State: -0- %, Private: 88 %

South
Federal: 8.2 %, State: 13.3 %, Private: 78.5 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

North: Federal Lease: USGS021807, State Permit: KR-57B
(if any)

South: Federal Lease: USGS041765, State Permit: ____________
(if any)

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: 168 acres
(including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: 406 acres

(C) Revegetated (Seeded and for Growing): 355 acres

(D) "Orphan Spoils" and Open Water: 500* acres See #14 below

(E) Support Facilities, Transportation Routes: 165 acres

(F) "Inactive" 352 acres

13. Average Analyses of Coal:

Name of Coal Seam 2nd, Moisture 35.17%, Ash (wet) 7.21 %

Sodium (wet) 3.56% Sulfur (wet) .78 %, Btu (wet) 7000 per lb.

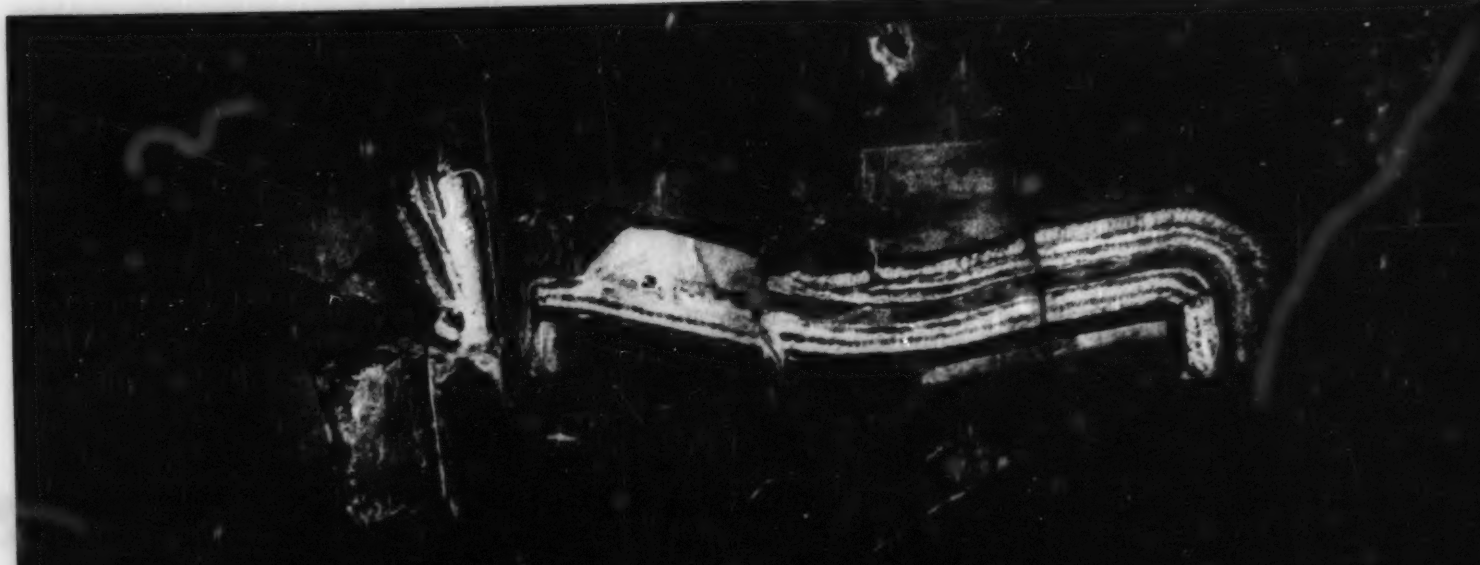
Name of Coal Seam Average, Moisture 36 %, Ash (wet) 8 %

Sulfur (wet) 1-1.5 %, Btu (wet) 6900 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

*Knife River and the North Dakota Game and Fish Department have a lease agreement covering this area. We are developing the area for wildlife habitat and fishing. Two ponds are under development presently, one of which is stocked with trout.

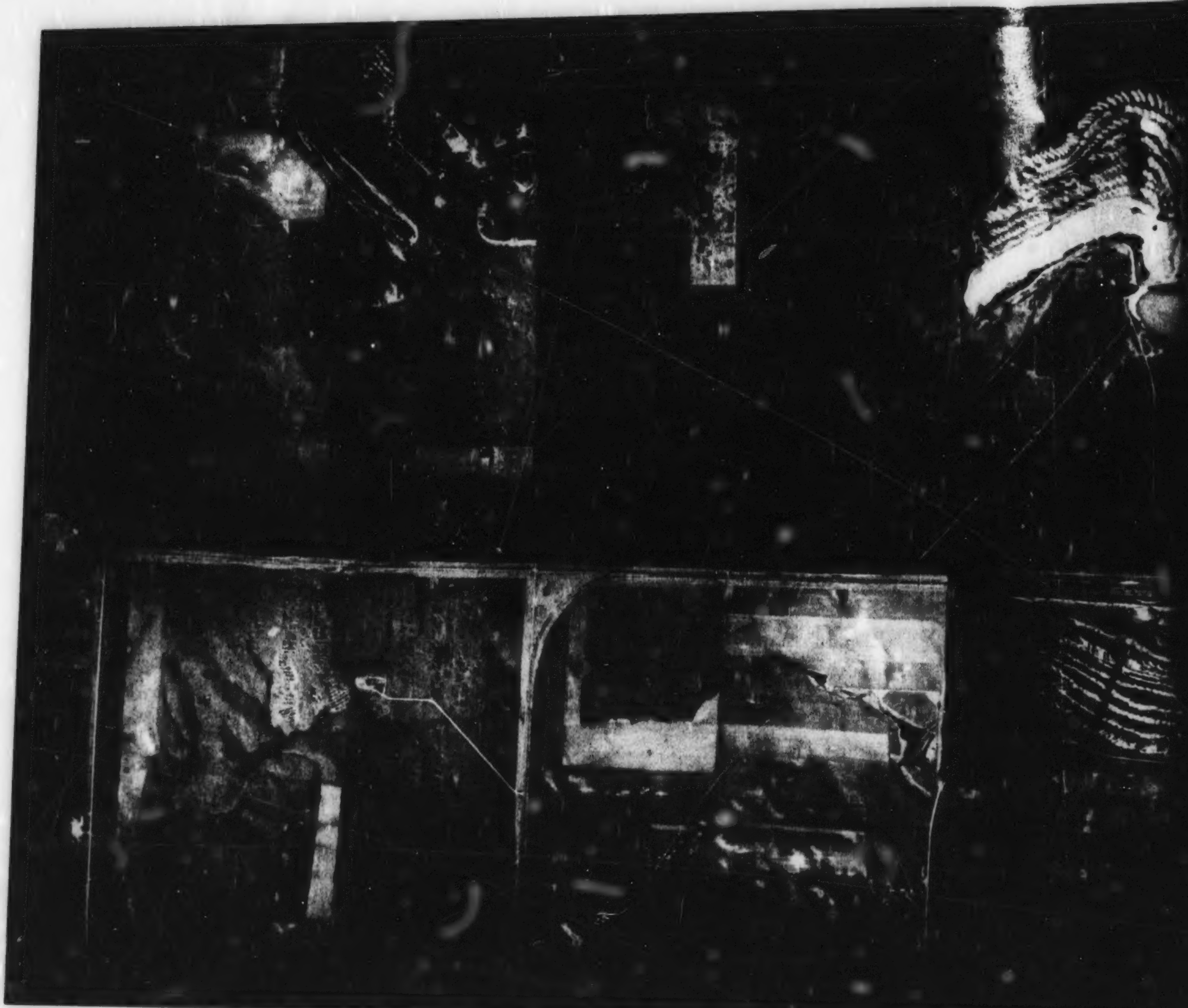
The unleveled spoil bank areas are serving as habitat for pheasant, deer, rabbits, etc.



0
0.5
1
MILES
N

PLATE 27a

BEULAH SOUTH MINE
Knife River Coal Company
Mercer County, North Dakota
23Jul74 1457-1515 hrs



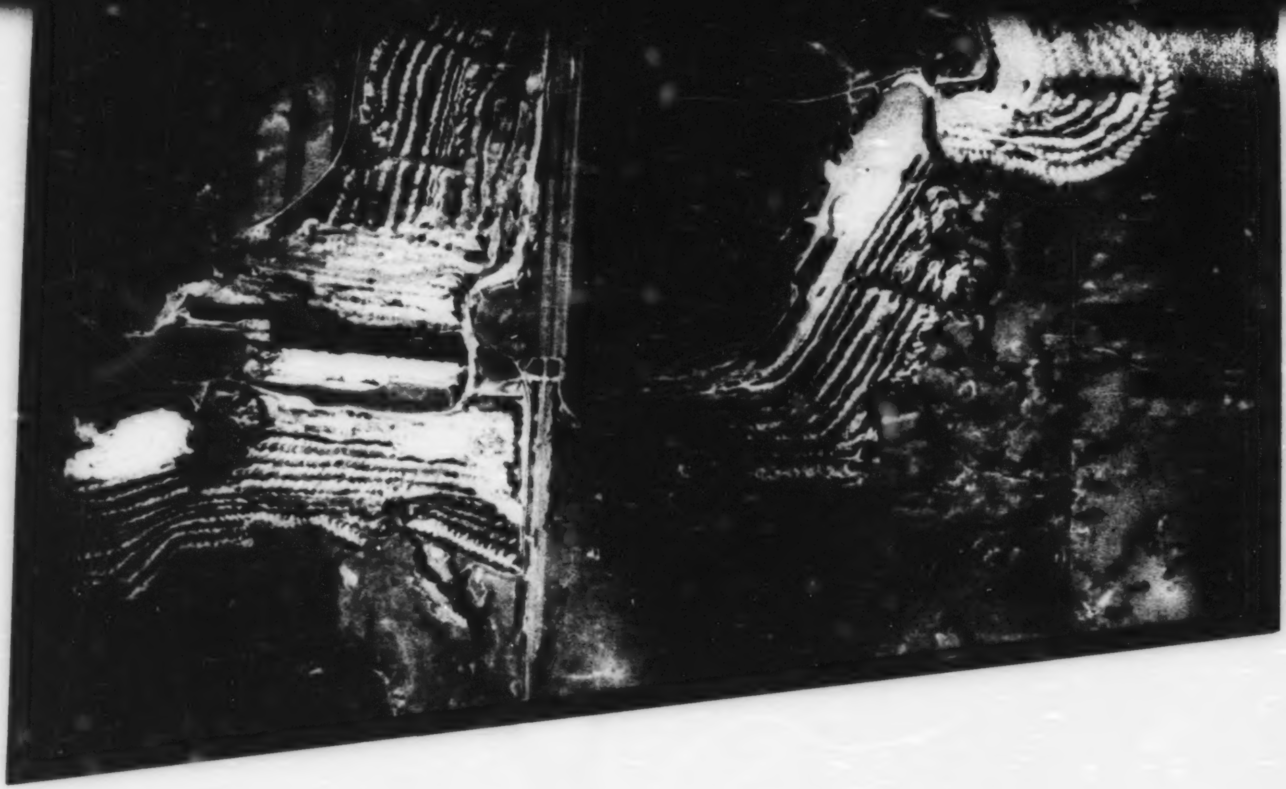


PLATE 27b

BEULAH NORTH MINE
Knife River Coal Company
Mercer County, North Dakota
23Jul74 1520-1528 hrs

0
0.5
1
MILES
N

Section 5-17
Indian Head Mine - Plate 28

This mine is represented by a mosaic of true color, low altitude, photography flown on 23 July 1974. As do most of the established mines in North Dakota, the Indian Head Mine shows extensive grading and seeding, "bevelled" spoil piles and "no-grading" topography, somewhat a function of the accepted mining practices of the past and present.

Grading and seeding is most extensive in the areas surrounding the two major elongated impoundments in the southern portion of the mine and in the more recently-mined area to the north. Emergence of vegetation is shown by the green tinges in the southern areas. The brownish area straddling the road bordering the north edge of the southern mined area has also received varied reclamation treatments with some success.

This mine is now also the site of extensive experiments relating to hydrology and reclamation activities.

DESCRIPTION OF MINE

1. Mine: Indian Head

2. Location: State: North Dakota (all acreage on which present corporate owners have conducted or are conducting operations)

County: Mercer Township: 144N
Range: 88W Sec: 28-33, 19

County: Mercer Township: 143N
Range: 88W Sec: 6

County: Mercer Township: 144N
Range: 89W Sec: 24-26, 36

County: Mercer Township: 143N
Range: 89W Sec: 1

3. Mine Operators: North Amercian Coal Corporation

4. Production Rates: For Year 1974: 1,090,144 tons per year
Estimated or Projected for Year 1974: 1,270,259 tpy
Monthly Average for 1974: 105,854 tons per month

5. Destination of Coal: (A) Estimated tons per year (1,040,000) to
Stanton, ND — City, State
Steam Electric — Use
(United Power Assoc)

6. Description of Long-Haul Transportation (reference 5 above):
(A) Unit Train (e.g., unit train), Ownership: Burlington Northern, # Cars 40 per train 30-mile, 1 per day
Approximate rate of car loading 10 min. per car (100 ton)
Storage Capacity for loading 250 tons.

7. Stratigraphic Data:
(A) Average Overburden Thickness 45 feet; range 20 to 65 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
(Clay, Sandstone)
Beulah-Zap 10
(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
___, ___, ___
Deeper Seams Spaer Bed ≈20' thickness and approximate separation from mined seams. (below mined bed, ≈3' thick)
(D) Depth of Active Pit: (feet) Average 45, Maximum: 65
Minimum: 20
(E) Bulking Factor for Spoils: 20 % (estimated)

8. Major Operating Equipment:

Draglines:	B-E 800W model	28 (cuyd) capacity	200 (ft) boom length	965/1240 (hp) power rqmts
Shovels:	B-E 150B model	10 (cuyd) capacity	43 (ft) max. radius	350/875 (hp) power rqmts
Trucks:	2 number	KW Dart D4651 model/power	120 (tons) capacity	
	4 number	Mack-Dart model/power	60 (tons) capacity	
Scrapers:	2 number	Cat #637 model/power	24 (cuyd) capacity	
Dozers:	1 number	Cat #12 Grader model/power	(cuyd) capacity	
	2 number	Cat 824B Dozer model/power	(cuyd) capacity	
	2 number	Let-West 777 Grader model/power	(cuyd) capacity	
	1 number	Cat D9G Dozer model/power	(cuyd) capacity	
Drills:	1 number	Twin-Arm Parmanco Coal Drill model/power	(cuyd) capacity	
Front End: Loaders	1 number	model/power	6 (cuyd) capacity	
Water Trucks:	number	model/power	(cuyd) capacity	

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 43

50 in July, 1974 2 shifts, 5 days dragline 1 shift, load

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: 43, In Headquarters: 3

(C) Contract Labor: Average for 1973: ______, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number
Hazen, North Dakota	2
Beulah, North Dakota	23
Zap, North Dakota	23

Not in named town: 2

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: 48 %, State: 32 %, Private: 20 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: #020273 (Bismarck), State Permit: No. 25 (P.S.C. #)
(if any)

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: 250 acres
(including areas leveled for dragline or shovel) (including inventory areas)

(B) Spoils Regraded or Being Regraded: 675 acres

(C) Revegetated (Seeded and for Growing): 575 acres

(D) "Orphan Spoils" and Open Water: 600 acres

(E) Support Facilities, Transportation Routes: 50 acres

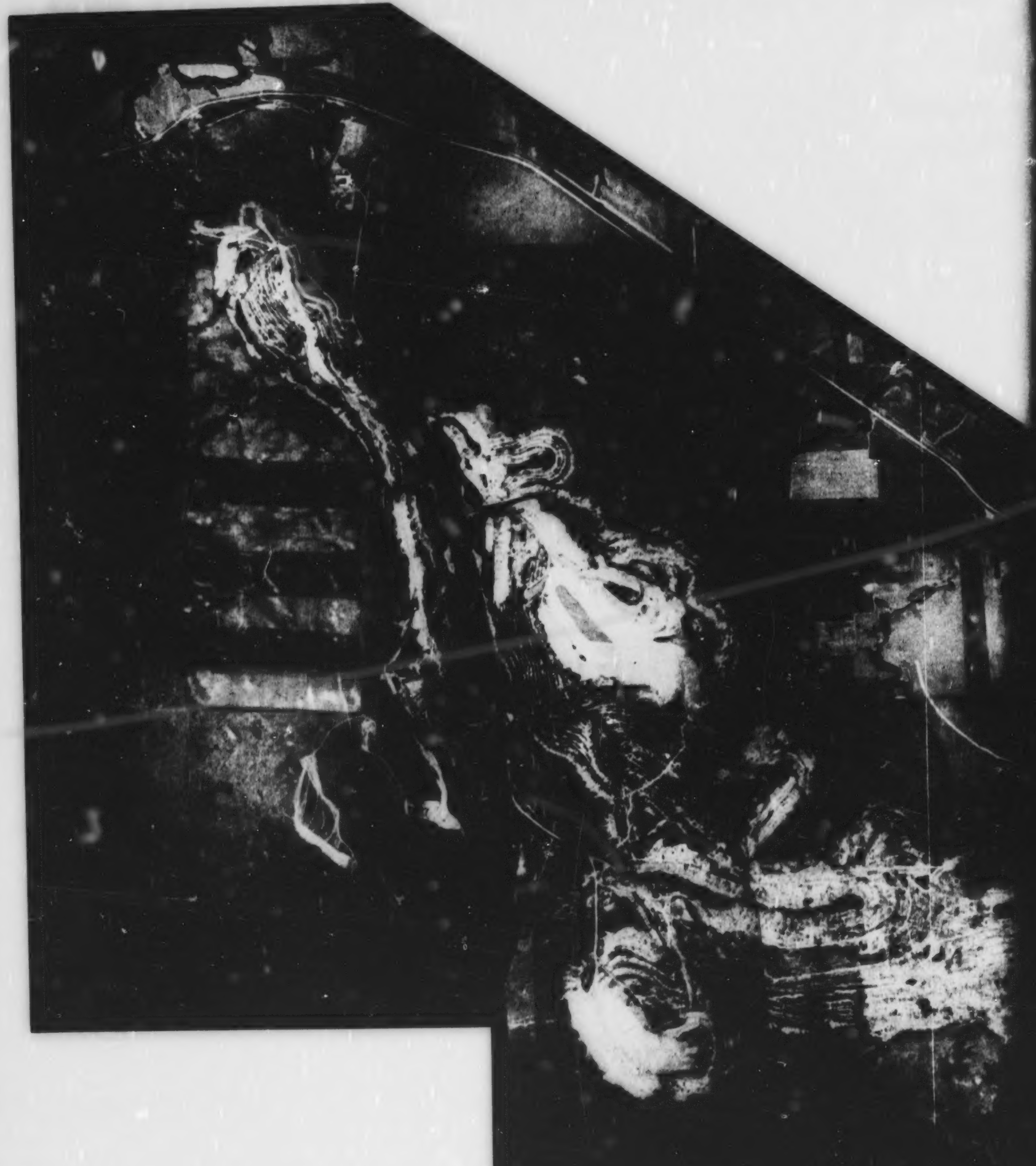
13. Average Analyses of Coal:

Name of Coal Seam Beulah-Zap, Moisture 30-35%, Ash (wet) 6-7 %

Sulfur (wet) 2-7 %, Btu (wet) 6800-7200 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Reserves estimated 200,000,000 tons.
Blasting Coal AN-FO and 60% dynamite, 10' spacing.
Pit Width: 100' to 120'
Minor water inflow to pit requiring periodic pumping.



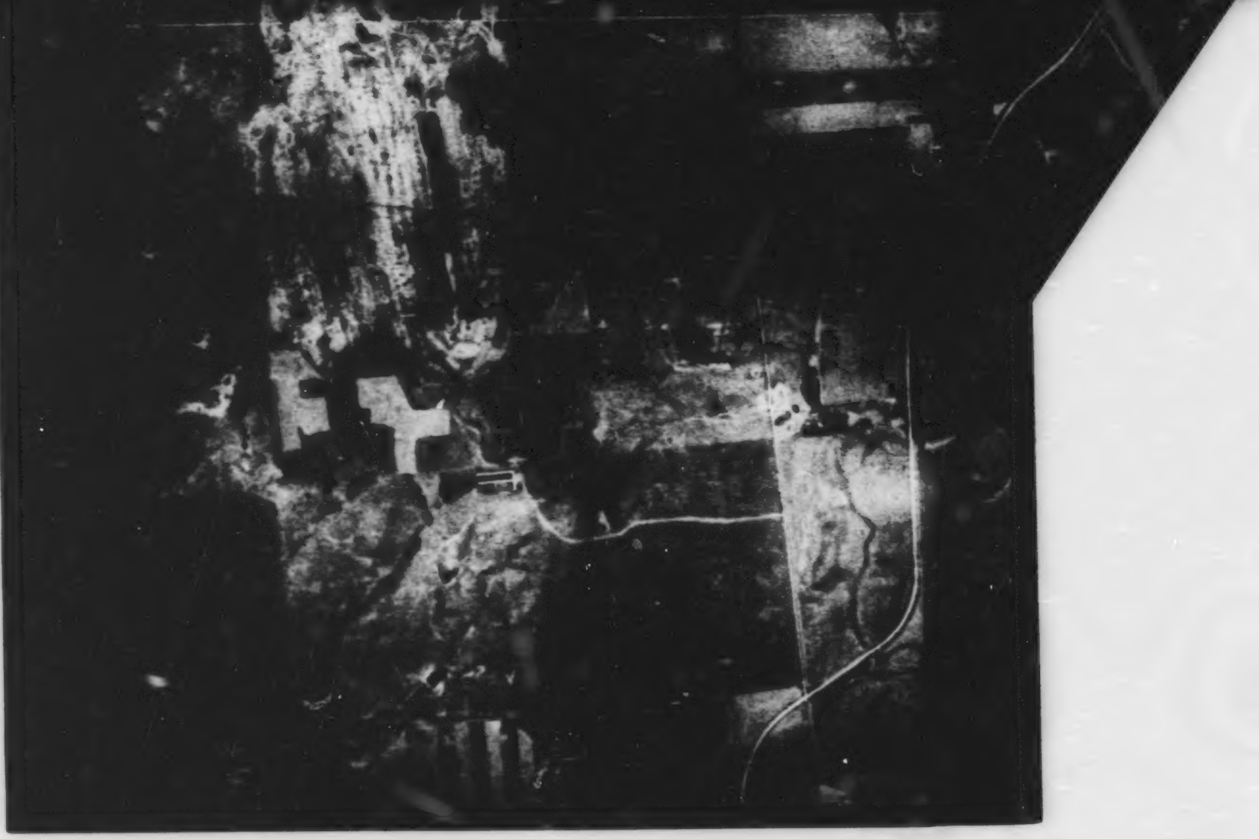


PLATE 28

INDIAN HEAD MINE
North American Coal Company
Mercer County, North Dakota
23Jul74 1322-1414 hrs

0
0.5
1
MILES
N

Section 5-18
Underwood Mine - Plate 29

This mine, in the past a relatively small operation and closed in 1973, is represented in true color, low altitude photography collected on 27 July 1974. Extensive reclamation is not apparent, but vegetative growth has migrated into the disturbed lands, especially where the spoil piles are somewhat leveled. The area shows signs of a relatively shallow ground water table and water is standing in the open pit areas.

A new mine is now planned for this Underwood area and is to be called Falkirk. This new activity is not represented in aerial photography in this report, but extends east from the existing mine. No data are available for the previous operation.

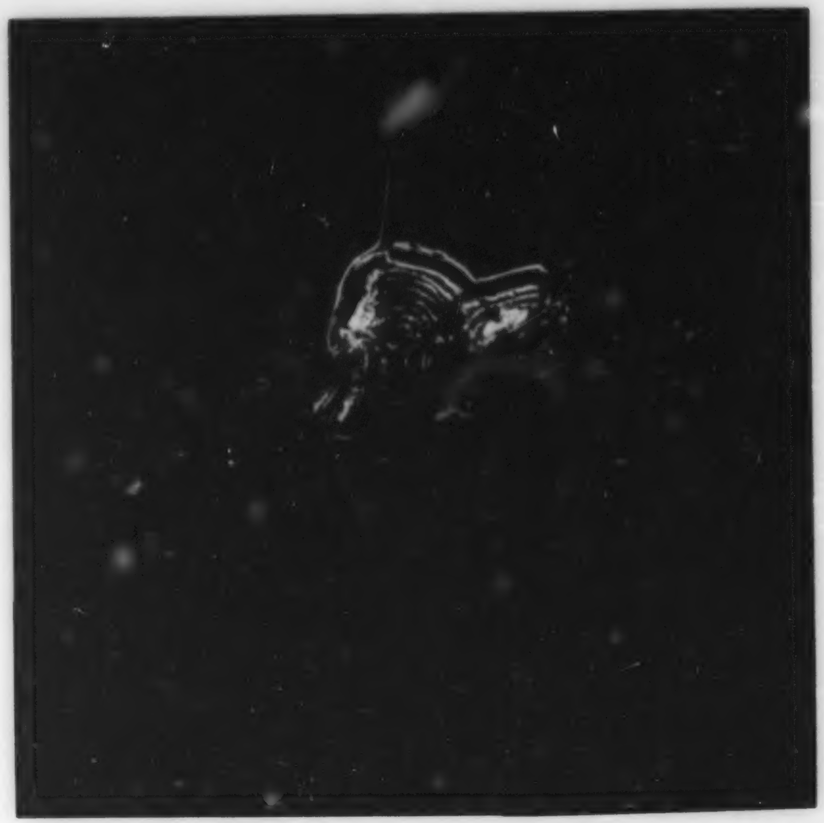


PLATE 29

UNDERWOOD MINE
Underwood Coal Company
McClain County, North Dakota
27Jul74 1230-1232 hrs

0
0.5
1
MILES
N

Section 5-19
Velva Mine - Plate 30

This mine has been a relatively extensive one as is shown by the low altitude photography presented as a mosaic in Plate 30. The imagery was collected on 22 July 1974. The northeastern area of the mined land shows vegetative growth on the north and east sides of spoil ridges. The southern portion of the mined area shows the effect of leveling the top of larger spoil ridges. There, vegetation occurs in a relatively even pattern over much of the area. Along the extreme western area of the disturbed lands, the vegetation shown in the imagery appears to simulate the vegetation and biological ecosystem south of the mined area.

Mining is progressing southwestward in the center of the mine. A number of impoundments are visible. Again, this is in a region of glaciation.

DESCRIPTION OF MINE

1. Mine: Velva

2. Location: State: North Dakota County: Ward (McHenry) Township: 152N
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 81W Sec: 35,36, 28, 34
County: Ward (McHenry) Township: 151N
Range: 81W Sec: 1, 2

3. Mine Operators: Consolidation Coal Company

4. Production Rates: For Year 1974: 428,163 tons per year
Estimated or Projected for Year 1974: 548,000 tpy
Monthly Average for 1974: ______ tons per month

5. Destination of Coal: (A) Estimated tons per year (70,000) to
East Grand Forks, Minnesota — Sugar Beet Plant
City, State — Use
(B) Estimated tons per year (24,000) to
Voltaire, North Dakota — Private Homes
City, State — Use
(C) Estimated tons per year (330,000) to
Voltaire, North Dakota — Steam Electric
City, State — Use

6. Description of Long-Haul Transportation (reference 5 above): Seven Mile Rail Spur
(A) Rail Road Cars (e.g., unit train), Ownership: Soo Line
______, # Cars 20 per train
(B) Rail Road Cars (e.g., unit train), Ownership: Consolidation Coal Company, # Cars ______ per train
(C) Rail Road Cars (e.g., unit train), Ownership: Basin Electric Power Company, # Cars 16 per train
Approximate rate of car loading 10 min. per car (100 ton)
Storage Capacity for Loading 2,000 tons

7. Stratigraphic Data:
(A) Average Overburden Thickness 68 feet; range 60 to 80 feet
(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)
Coteau 12
(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)
____, ____, ____ Deeper Seams ______ thickness and approximate separation from mined seams.
(D) Depth of Active Pit: (feet) Average ______, Maximum: ______
Minimum: ______
(E) Bulking Factor for Spoils: 20 % (measured; estimated)

8. Major Operating Equipment:

Draglines: 7400-M (model), 12 (cuyd) (capacity), 178 (ft) (boom length), ____ (kw) (power rqmts)

Shovels: P&H 1400 (model), 6 (cuyd) (capacity), ____ (ft) (boom length), ____ (kw) (power rqmts)

Trucks: 5 (number), DN-20 (model/power), 40 (tons) (capacity)

Scrapers: ____ (number), ____ (model/power), ____ (cuyd) (capacity)

Dozers: 2 (number), D-8 Cat (model/power), ____ (cuyd) (capacity)

Drills: ____ (number), ____ (model/power), ____ (capacity)

Front End Loaders: 1 (number), 988 (model/power), 6 (cuyd) (capacity)

____ (number), ____ (model/power), ____ (cuyd) (capacity)

Water Trucks: 1 (number), Euclid (model/power), 2500 (gal) (capacity)

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 33

33 in July, 1974 one shift

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: None, In Headquarters: None

(C) Contract Labor: Average for 1973: None, % of year worked ____%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number
Velva	22
Sawyer	4
Minot	3

Not in named town 8 (Number)

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: ____%, State: ____%, Private: 100 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ____, State Permit: (if any) #19 (80 acres) (Expires 1/1/76)

State Permit: #27 (124 acres) (Expires 10/16/77)

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: ___319___ acres (including areas leveled for dragline or shovel)

(B) Spoils Regraded or Being Regraded: _________ acres

(C) Revegetated (Seeded and for Growing): _10_______ acres

(D) "Orphan Spoils" and Open Water: _________ acres

(E) Support Facilities, Transportation Routes: _________ acres

13. Average Analyses of Coal:

Name of Coal Seam ________________, Moisture ____%, Ash (wet) ______%

Sulfur (wet) _______%, Btu (wet) _______ per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

Highwall instability has resulted in slides.
No blasting.
Pit width 100 - 110'.

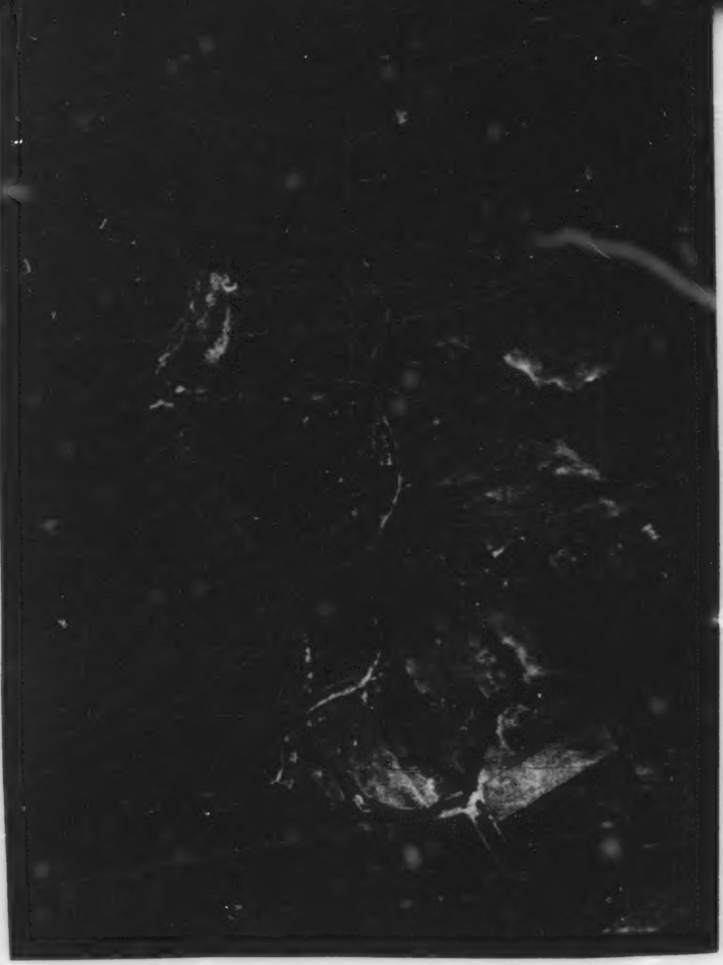


PLATE 30

VELVA MINE
Consolidation Coal Company
Ward County, North Dakota
22Jul74 1455-1457 hrs

0
0.5
1
MILES
N

Section 5-20
Noonan Mine - Plate 31

This mine, which has extended over a very large area, is represented on Plate 31. This true color photography was collected at low altitude on 22 July 1974. The area shows numerous areas of standing water and the imagery suggests a shallow water table. This is a region of thick glacial deposits.

Coal loading facilities are located at the north-central edge of the mined area. Other dark gray areas bordering the mined areas show where coal has been piled. New mining activities appear at the end of the road extending southeast from the central coal loading facilities. The total area represented in the mosaic extends a little over eighteen kilometers or eleven miles.

DESCRIPTION OF MINE

1. Mine: Noonan Mine (Larson)

2. Location: State: North Dakota County: Burke Township: 162N,
(all acreage on which present corporate owners have conducted or are conducting operations) Range: 94W Sec: 3,4,5,8,9,10,11,14,15,16

3. Mine Operators: Baukol-Noonan, Inc.

4. Production Rates: For Year 1973: 482,299 tons per year

Estimated or Projected for Year 1974: 400,000 tpy

Monthly Average for 1974: 40,192 tons per month

5. Destination of Coal: (A) Estimated tons per year (______) to

Larson, ND
City, State Use

(B) Estimated tons per year (300,000) to

Drayton, ND, Moorhead & Crookston, MN Process Sugar
City, State Use

(C) Estimated tons per year (20,000) to

Grand Forks, ND EGS
City, State Use

6. Description of Long-Haul Transportation (reference 5 above):

(A) Rail Road Cars (e.g., unit train), Ownership: Burlington Northern & Soo Line, # Cars 35 per train

Approximate rate of car loading 12 min. per car (100 ton)

Storage capacity for loading minimal tons

7. Stratigraphic Data:

(A) Average Overburden Thickness 40 feet; range 25 to 60 feet

(B) Name of Coal Seams Mined and Average Thickness in feet: (youngest to oldest)

Noonan 6

(C) Average Thickness of Partings Between Seams (feet): (youngest to oldest)

____, ____, ____ Deeper Seams ______ ______
thickness and approximate separation from mined seams.

(D) Depth of Active Pit: (feet) Average ______, Maximum: ______

Minimum: ______

(E) Bulking Factor for Spoils: ______% (measured; estimated)

8. Major Operating Equipment:

Draglines:	B-E 9W model	11 (cuyd), capacity	150 (ft), boom length	(kw) power rqmts
Shovels:	None model	(cuyd), capacity	(ft), max. radius	(kw) pwr rqmts
Trucks:	7 number	Euclid model/power	20 (tons) capacity	
Scrapers:	1 number	Cat model/power	21 (cuyd) capacity	
Dozers:	2 number	Graders model/power	(cuyd) capacity	
Drills:	number	model/power	(cuyd) capacity	
Front End: Loaders	1 number	Caterpillar 988 model/power	8 (cuyd) capacity	
Water Trucks:	1 number	model/power	(cuyd) capacity	

9. Employment:

(A) Number of full-time employees at the site: Average for 1973: 41

49 in July, 1974 3 shifts - 7 day dragline; 1 shift - 5 day loadi

(B) Number of other full-time employees employed off-site, but who are working essentially full-time for this mine: (Average for 1973)

In local area: 1, In Headquarters: ______

(C) Contract Labor: Average for 1973: None, % of year worked ___%

Type of Work:

(D) Places of Residence of Full-Time Employees (and approximate number residing there):

Town	Number
Noonan, ND	15
Columbus, ND	10
Flaxton, ND	2

Not in named town: 14

10. Coal Ownership: As of July 1974, currently covered by Mining and Reclamation Plan and by Permit:

Federal: 0 %, State: 0 %, Private: 100 %

11. Coal Lease and "Permit" Numbers: (as of July 1974)

Federal Lease: ______, State Permit: 24 (210 acres)
(if any) Expires 1/1/77

12. Disposition of Surface in July 1974:

(A) Active Pit and "Active" Spoils: ≈ 75 acres
(including areas leveled for
dragline or shovel)

(B) Spoils Regraded or Being Regraded: ≈ 145 acres

(C) Revegetated (Seeded and for Growing): ≈ 150 acres

(D) "Orphan Spoils" and Open Water: ≈ 450 * acres

(E) Support Facilities, Transportation Routes: __________ acres

(F) "Inactive": 360 acres

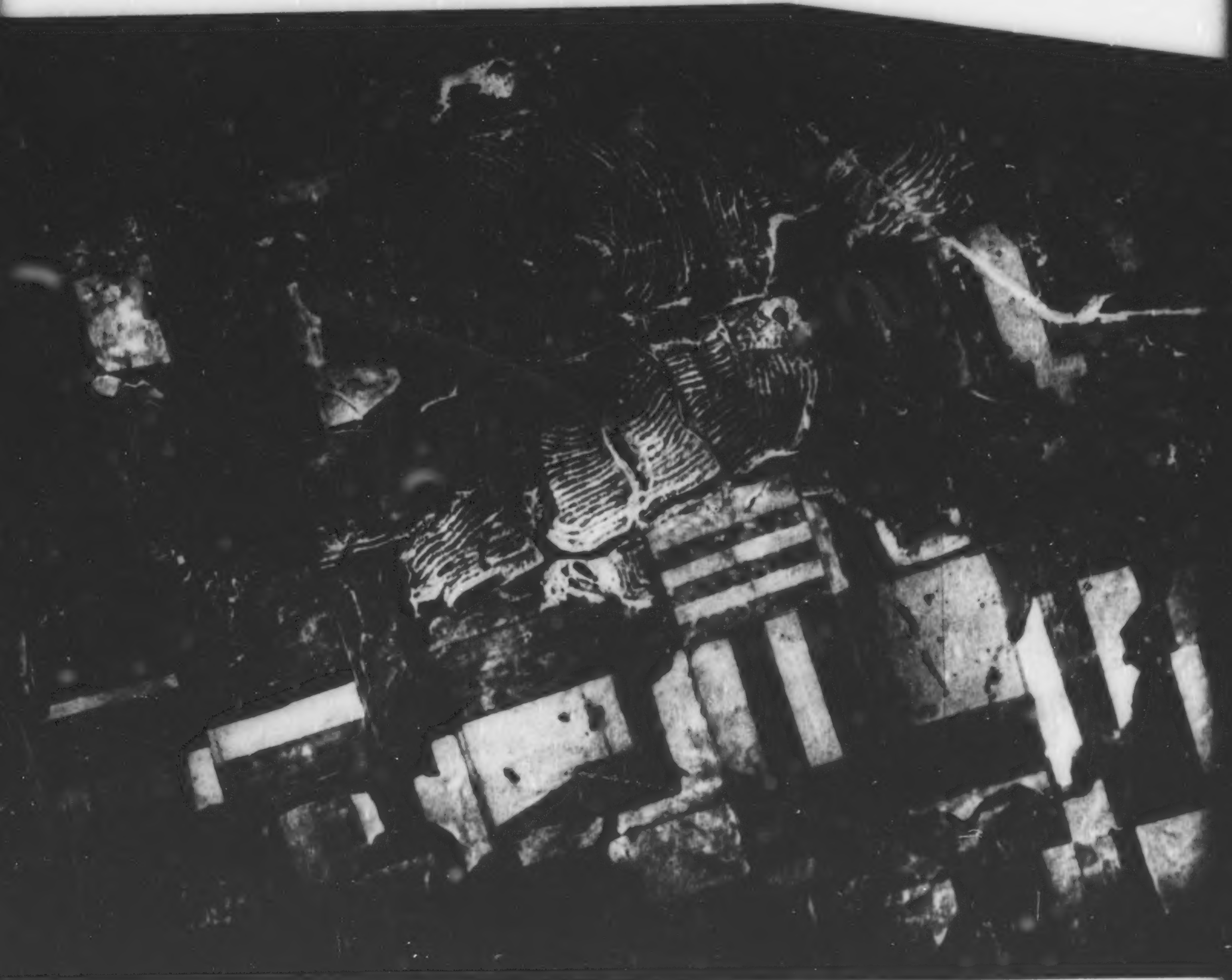
13. Average Analyses of Coal:

Name of Coal Seam Noonan, Moisture 33-36%, Ash (wet) 6-7 %

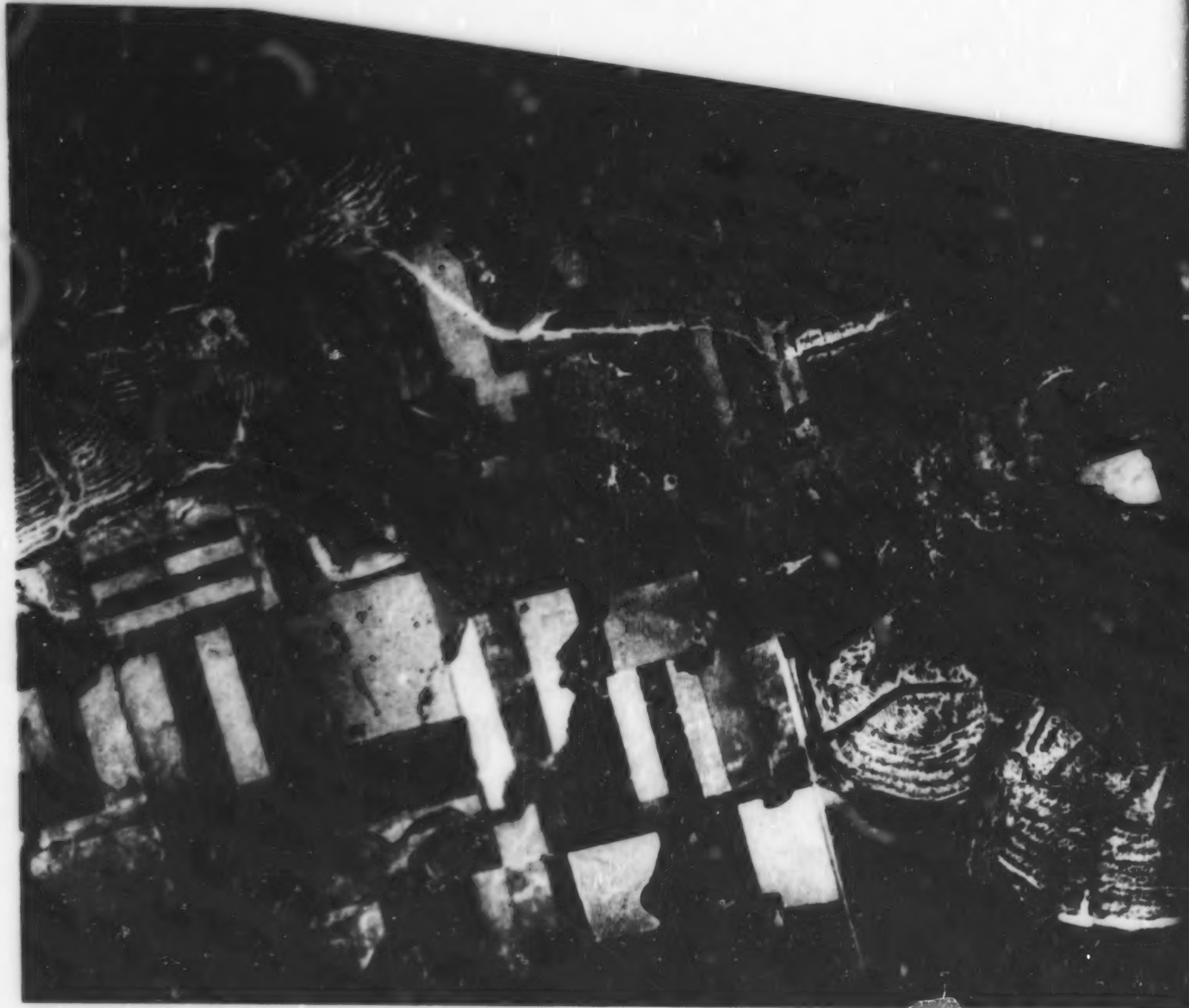
Sodium: 3-7 %, Sulfur (wet) .5 %, Btu (wet) 7250 per lb.

14. Other Items of Interest such as previous (historical) methods of mining including underground, water-bearing strata encountered, amount of water removed from workings, water quality data.

*A great deal of work was done during the years 1963 to 1969 in converting the mined land into a wildlife habitat. Approximately 35,000 trees and shrubs were planted and a program of aerial seeding of grasses and legumes was carried out during this period. The results have been good and the area abounds with wildlife of all kinds.



See following page for title. Photograph presented in two parts with center repeated.



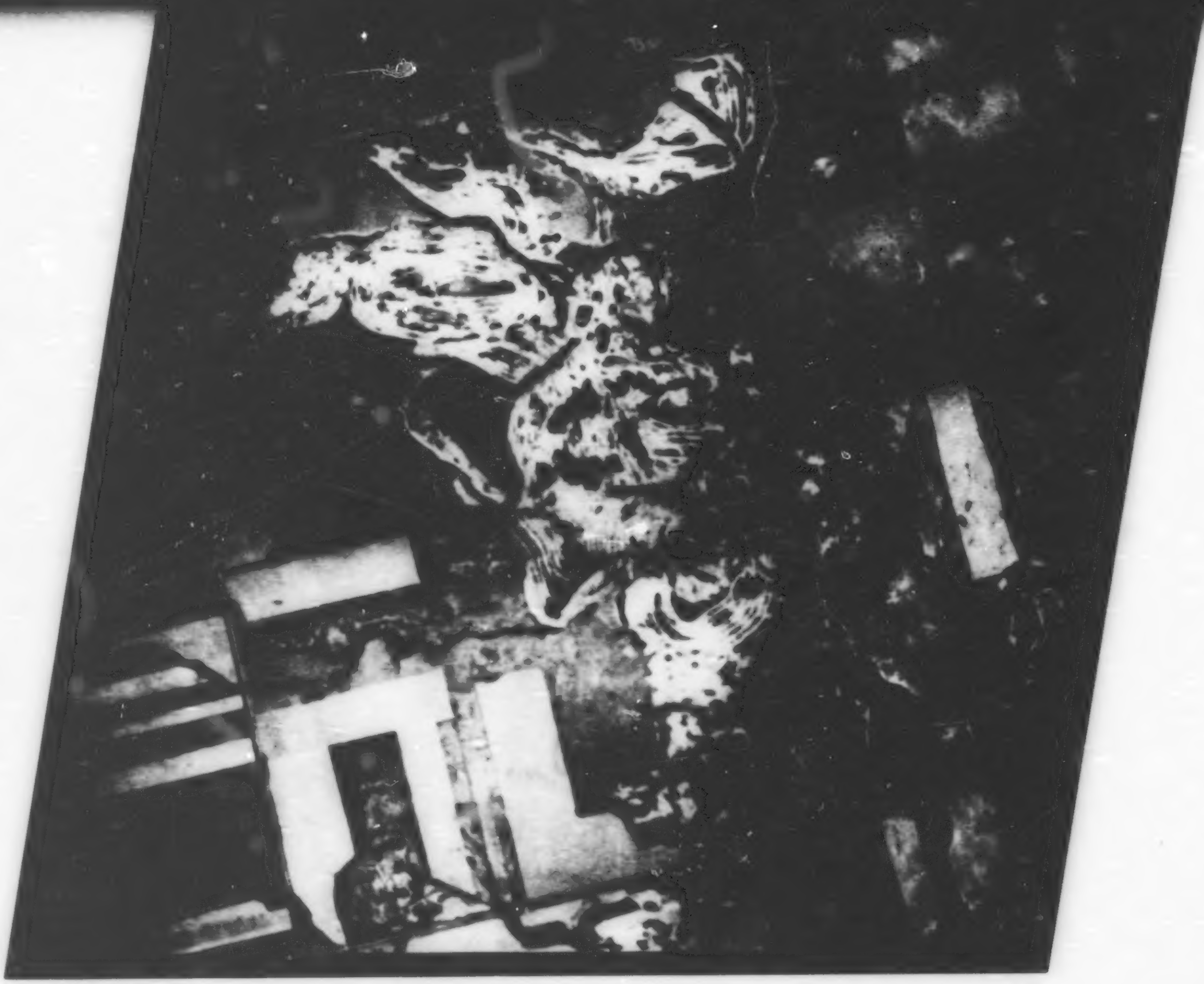


PLATE 31

NOONAN MINE
Baukol Noonan Inc.
Burke County, North Dakota
22Jul74 1150-1224 hrs
(Two pages including preceeding page)

0
0.5
1
1.5
MILES
N

Section 5-21
Highland Uranium Mill and Mine - Plates 32 and 33

This uranium mine, located north of Douglas and Glenrock, Wyoming is represented here in low altitude true color photography collected on 19 and 24 July 1974. The middle "strip" of the mosaic (includes the mill and the tailings pond) was flown first and shows natural drainage channels in a darker brown hue since the remainder of the imagery was collected after some additional seepage and evapotranspiration of the springtime precipitation had taken place.

Vertical aerial imagery makes it somewhat difficult to "see" the open pit of this uranium mine located along the southern boundary of the mosaic. Therefore, we have provided an aerial oblique view of the mine area (Plate 33) and a ground-level view of the mine for perspective. The aerial oblique was collected on 19 July 1974 while the ground-level view was photographed in early June 1974.

"Statistical information" is not provided for this operation. Exploratory drilling is evident along the left (west) side of the mosaic. A north-south fracture pattern is also shown by striations in the area east of the mill. The area to the northeast of the mine pit is an overburden dump and shows vegetative growth. Diversion dams and ditches are located along the northern border of the tailings pond area. Seepage is evident downstream of the tailings pond dam.

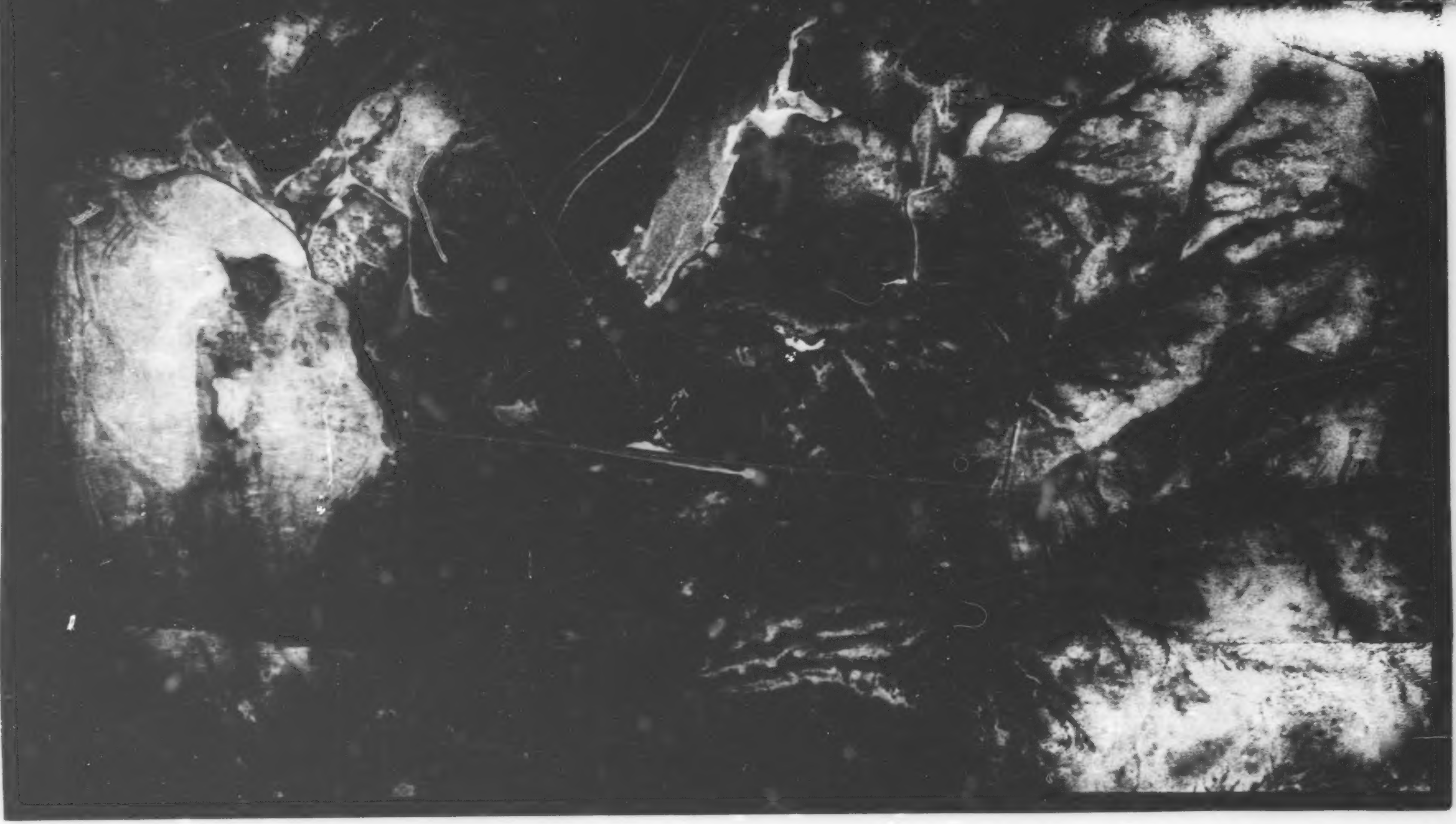
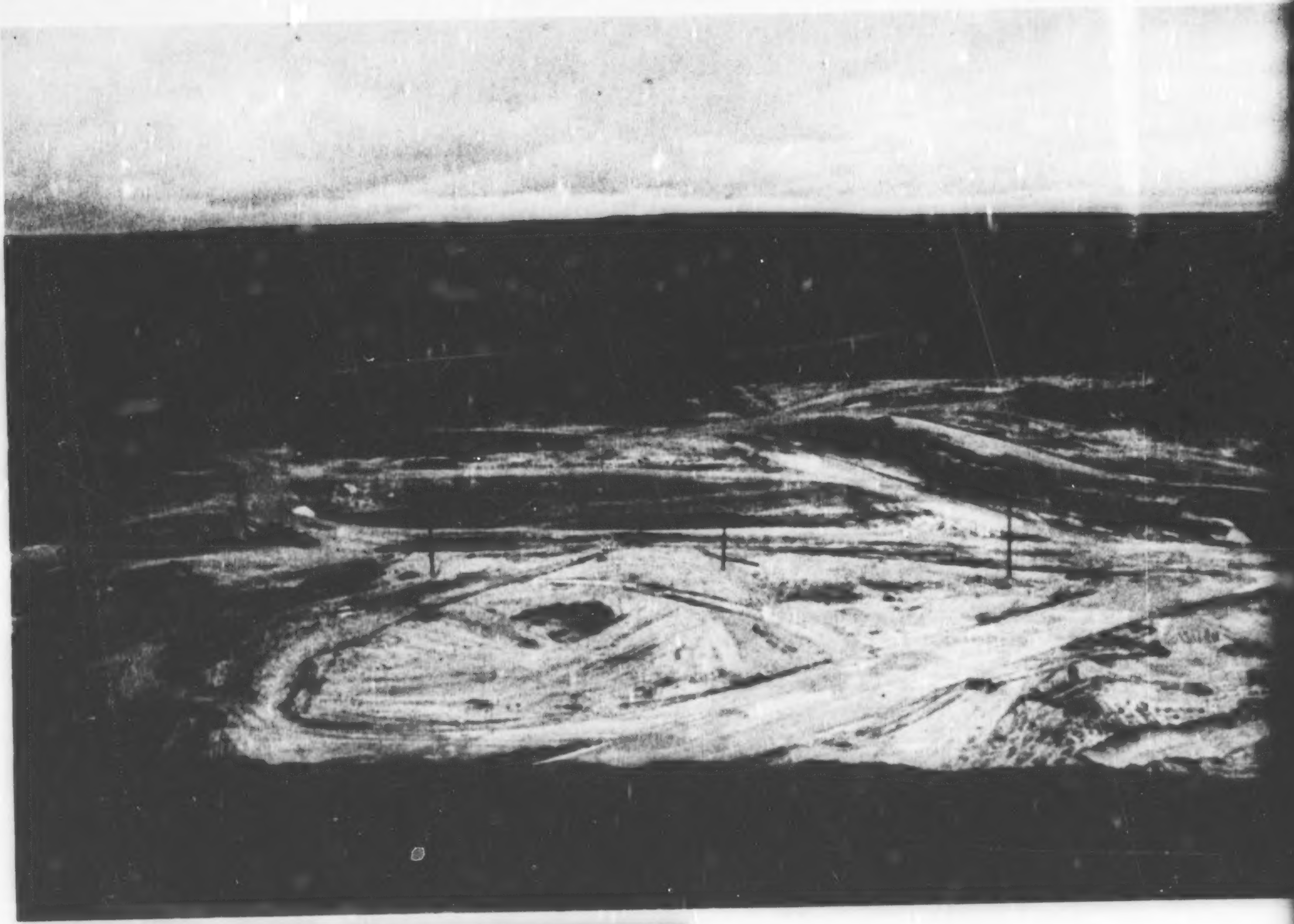
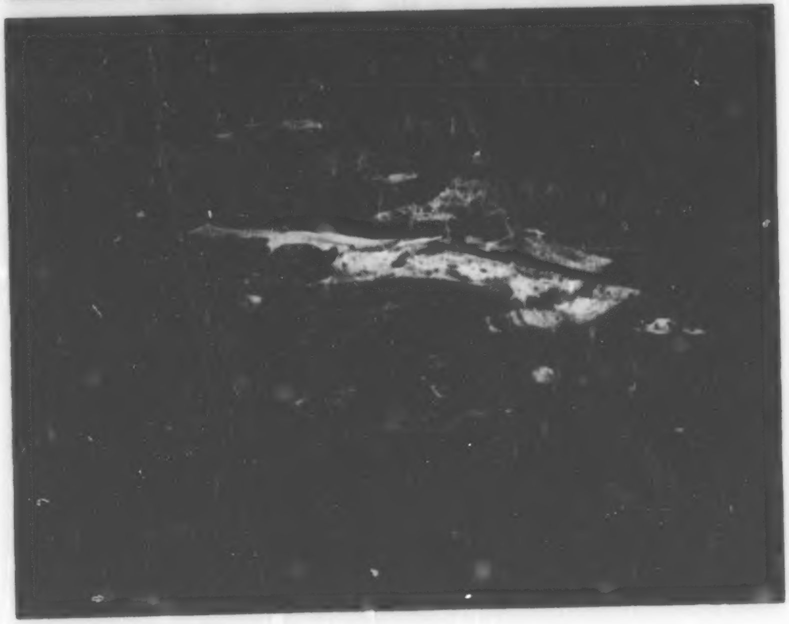


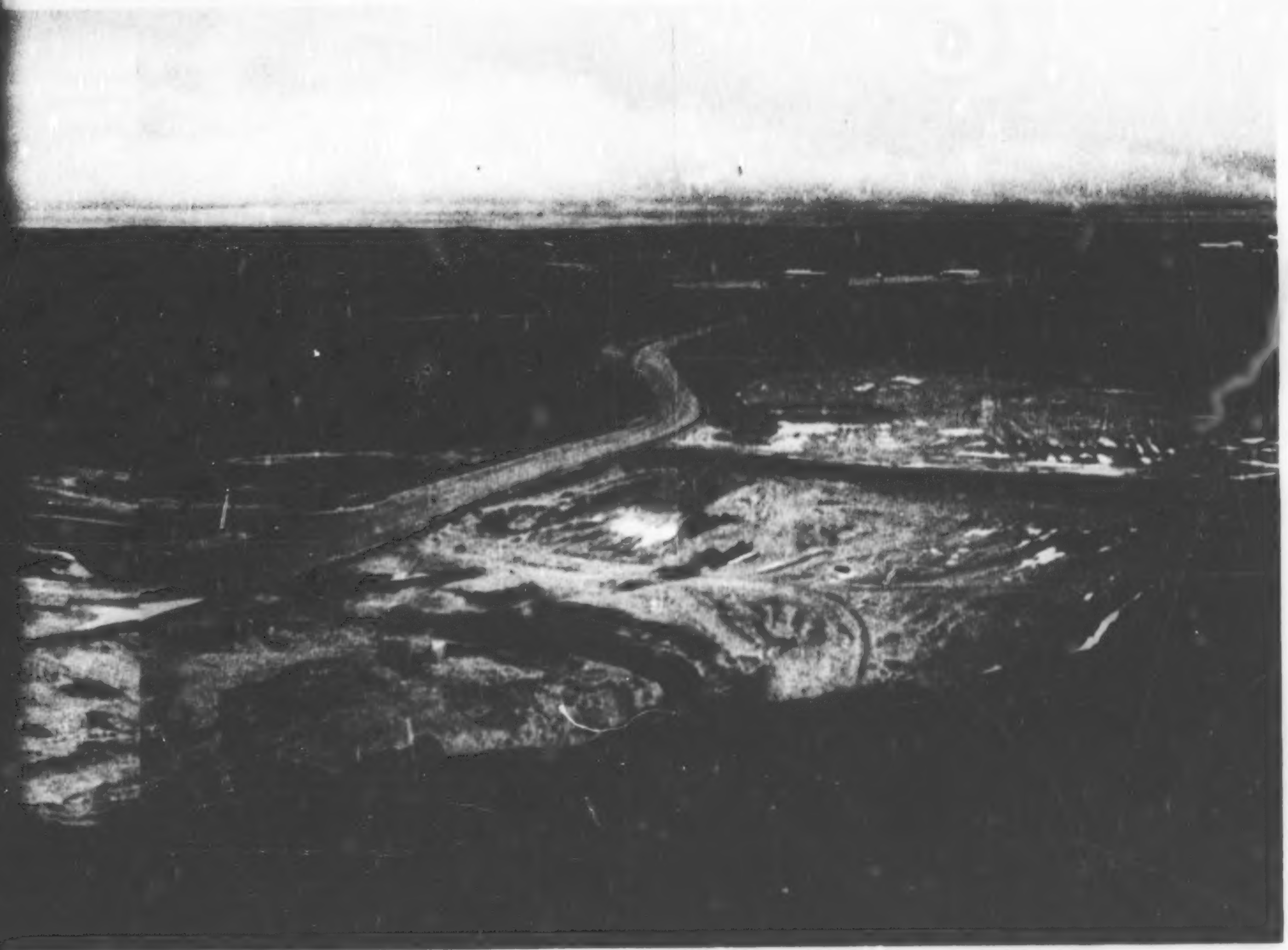
PLATE 32

HIGHLAND MINE (URANIUM)
Exxon
Converse County, Wyoming
19&29Jul74 1107-1139/1123-1124





Oblique Aerial
Horizon of picture is to the south.



Ground Panorama
Horizon of picture is to the southwest.

PLATE 33

HIGHLAND MINE (URANIUM)
Exxon
Converse County, Wyoming

CHAPTER 6

SATELLITE IMAGERY

During 1974, the EPA's National Field Investigations Center in Denver studied LANDSAT (or ERTS for Earth Resource Technology Satellite) imagery to determine its potential for showing the location, configuration, size, and condition of various "classes" of land at a surface coal mine site. These "classes" or conditions of land were defined as follows:

1. Area in which mining was active;
2. Area in which spoils have been deposited, but not yet regraded;
3. Area of spoils recontoured or graded;
4. Area of regraded spoils seeded, planted, or revegetated;
5. Areas on which vegetation is growing and the condition of the vegetation.

The results of this study are discussed in more detail in a report published by the EPA.* The following discussion represents a summary of the essential findings of the study.

The study utilized computer classification to identify various coal mine related land use activities in four spectral wave length bands (green, red, near infrared, and far infrared). The computer-assisted program was an adaptation of a routine developed by Purdue University designed to classify agricultural lands. The program operates by reading the optical intensity of a small area of the imagery, a function of reflectance of sunlight, and determining, based upon readings made in areas of known land uses, whether new areas correlate with "training" areas. The program examines each increment of the computer tape of the satellite imagery where an increment is determined by the scanning capacity of the satellite equipment and equals a ground area of 4,860 square meters for the imagery used. This increment is characterized by a single optical intensity which is equal to the average reflectance obtained by the sensor as it scanned that 4,860 square meter area on the ground. The single data point or value is often termed a "pixel". The larger the size of the pixel, the less definition or resolution contained in the imagery.

The classification program is "trained" by having it examine pixels on all four wave length bands collected over an area of known land use or an area where the optical intensities of the pixels are equal on any one wave length band (i.e., a "training area"). The program then examines a different area and statistically determines the confidence within which each new pixel matches previously-examined "training" areas. Obviously, the program lends itself to improving classifications as an analyst compares the statistical confidences with ground truth data.

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*EPA National Field Investigation Center, "An Application of ERTS Technology to the Evaluation of Coal Strip Mining and Reclamation in the Northern Great Plains," Feb., 1975.

The ERTS imagery study attempted land classifications according to the degree of disturbance (e.g., active mine, spoil piles, graded, revegetated, undisturbed). It was found that the program could distinguish between land uses which had high contrast in terms of reflectance such as water and open pits delineated by abrupt topographic breaks (highwalls and low walls) as compared to natural or regraded terrain. However, the boundaries of vegetated areas were less accurately defined. Areas from which vegetation had been leveled or soil had been removed could not be easily distinguished from spoils or graded lands.

It is concluded that satellite imagery requires detailed ground truth data that can also be obtained to a large degree through the use of lower altitude photography. Thus, it is felt that the satellite imagery does not have the same potential for use as a planning and regulatory tool for surface coal mining as does imagery obtained from altitudes of 2,000 to 20,000 meters.

A representative analysis of the Dave Johnston Mine, located north of Glenrock, Wyoming, using satellite imagery is provided in Figures 1 through 4. Figure 1 is a map provided by the operating companies showing the revegetated areas as of 1973. Figure 2 shows the satellite image of the mine site obtained on 18 August 1973. Figure 3 is the classification map prepared after use of the 1973 map and low altitude photography. Figure 4 compares the classifications with the mine. Table 3 summarizes the land areas affected by the mining activities at the Dave Johnston Mine in Wyoming as of 1973.

TABLE 3

Aerial Distribution of Land Use
Dave Johnston Mine

Land Use	Pixels	Area Hectares	Acres
Highwall and Spoils and Active Pit	508	247	610
Northwest Portion of Mine			
Spring 1973 Revegetation	26	13	31
Topsoil Borrow	7	3	8
Spring 1972 Planting	67	33	80
Spring 1971 Planting	17	8	20
Fall 1970 Planting	33	16	40
Fall 1969 Planting	46	22	55
	196	95	234
Southeast Portion of the Mine			
Spring 1972 Planting	30	15	36
Fall 1972 Planting	36	18	43
Fall 1972 Planting and Topsoil Borrow in Southwesternmost Corner	368	179	442
	434	212	521
Total Mine Area	1,138	554	1,365

As shown in Figure 1 about 55 percent of the disturbed areas of the mine has been replanted. The computer classification defined the disturbed areas but difficulty was encountered in separating older revegetated areas from undisturbed native vegetation. This separation was achieved using Figure 1. Difficulty was also encountered in defining the highwall location in the northwestern area of the mine during the initial classification. The highwall was then defined by preparing a ratio image of the green band to the infrared 1 band. The composite map (Figure 3)* of the classifications of various mine areas was prepared using both the ratio image and the multi-spectral classification.

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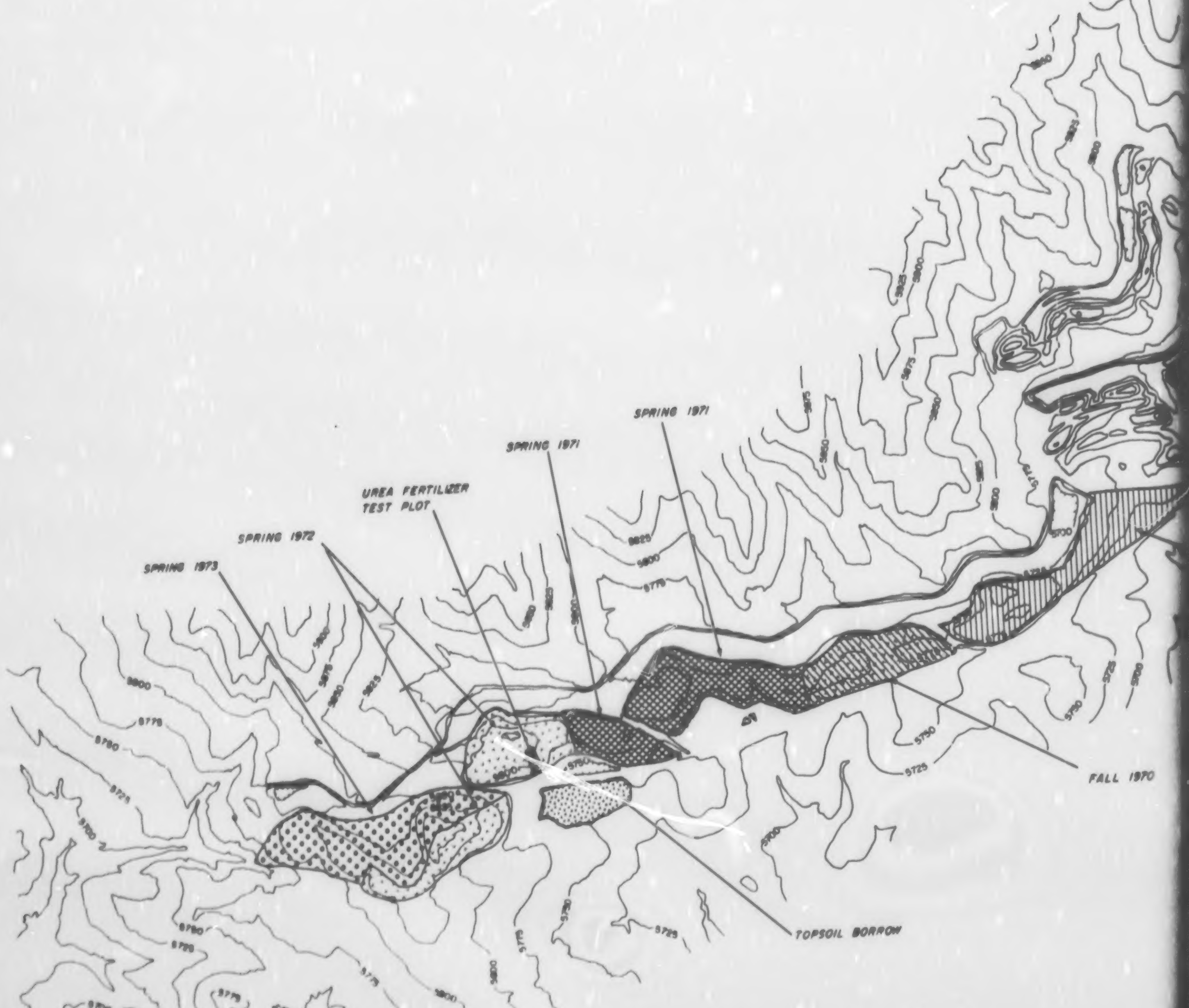
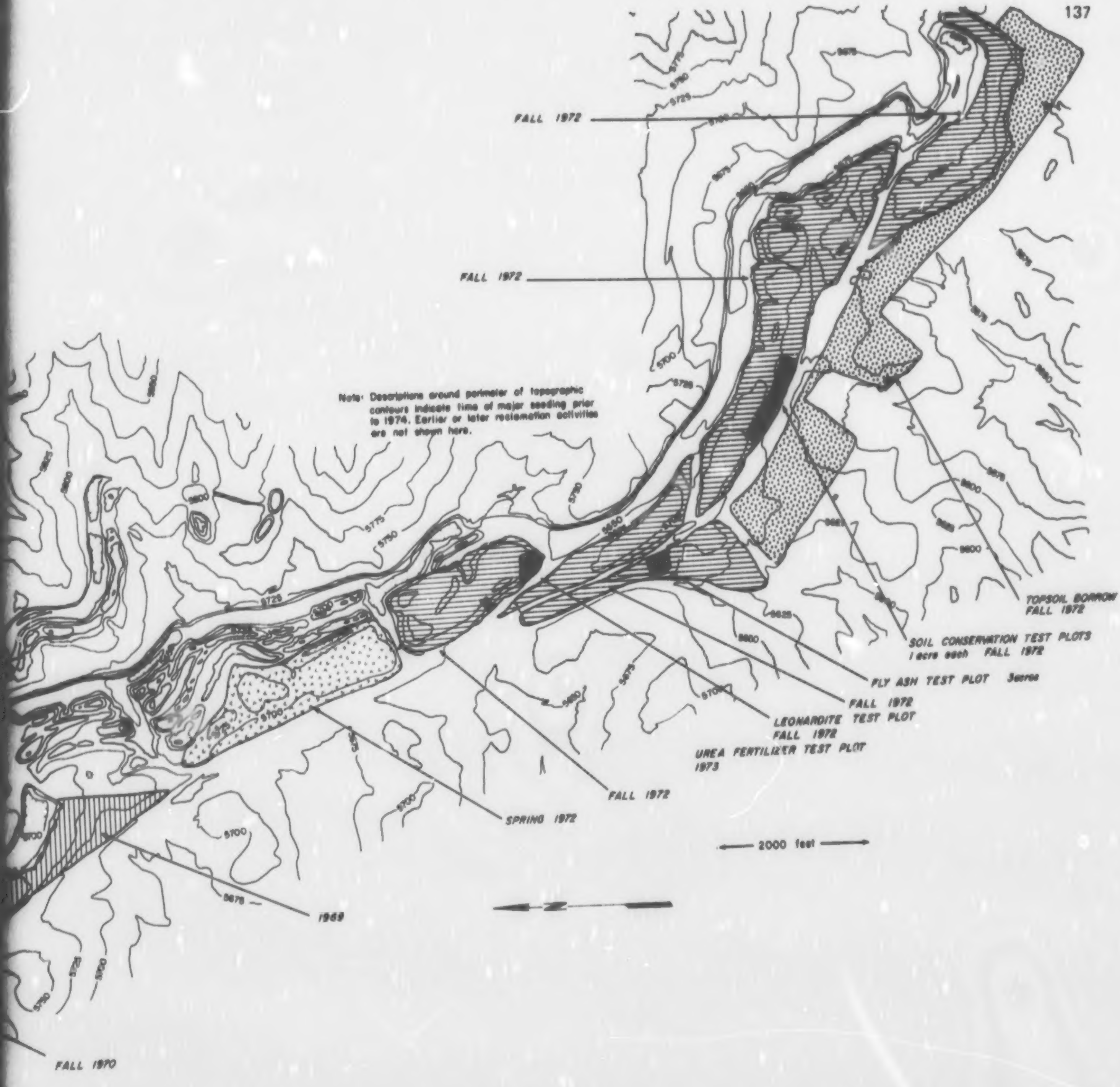
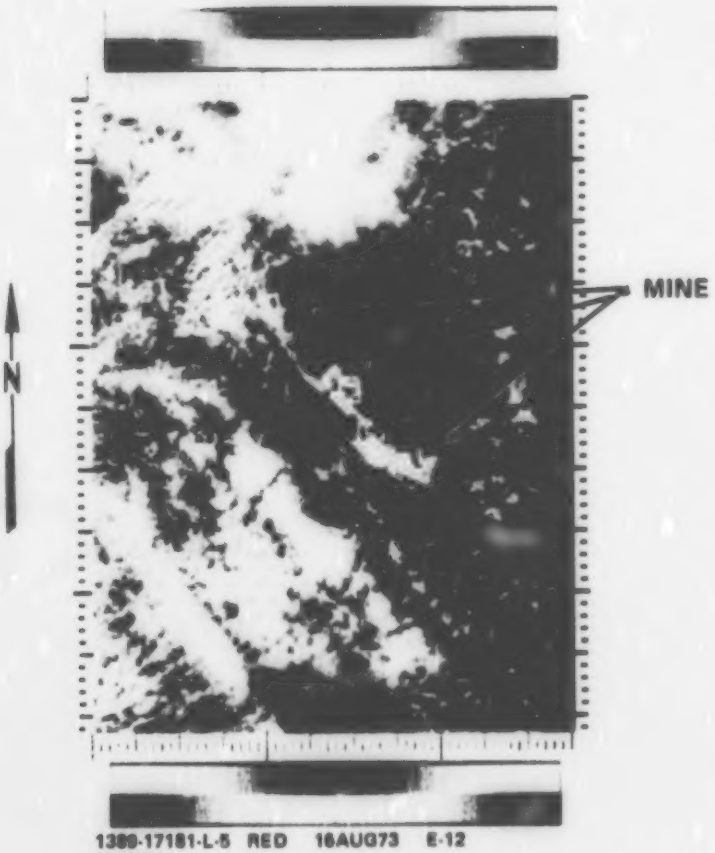
*Some scale distortion is inherent in producing an overlay map (on the computer line printer) which can be avoided only by additional processing. In scaling overlay maps to USGS topographic maps, the longitudinal axis of the former must be reduced to 80% of its normal value.


SPRING 1971
SPRING 1971
UREA FERTILIZER TEST PLOT
SPRING 1972
SPRING 1973
FALL 1970
TOPSOIL BORROW
5900
5875
5850
5825
5800
5775
5750
5725
5700


FALL 1972
FALL 1972
TOPSOIL BORROW
FALL 1972
SOIL CONSERVATION TEST PLOTS
1 acre each FALL 1972
FLY ASH TEST PLOT 3acres
FALL 1972
LEONARDITE TEST PLOT
FALL 1972
UREA FERTILIZER TEST PLOT
1973
FALL 1972
SPRING 1972
1969
FALL 1970
2000 feet
N
5700
5725
5750
5775
5800
5675
5650

Note: Descriptions around perimeter of topographic contours indicate time of major seeding prior to 1974. Earlier or later reclamation activities are not shown here.

FIGURE 1. REVEGETATION OF DAVE JOHNSTON MINE
(After a composite map prepared by Pacific Power and Light Company ca. 1973-4)



1389-17181-L-5 RED 16AUG73 E-12
(N.G.P.)
C N43-11/W105-43 S N43-08/W105-31 HDG 191
SUN EL52 AZ133 5424
APPLIED SKEW = 2.81 DEGREES. ASPECT =
1,393861
**STRIP MINE NO. 4 **
INSERT
ASTRTCH2
STRETCH 65-132
JDA AUG 19, 1974 124052 JPL/IPL

FIGURE 2. SATELLITE IMAGE OF DAVE JOHNSTON MINE

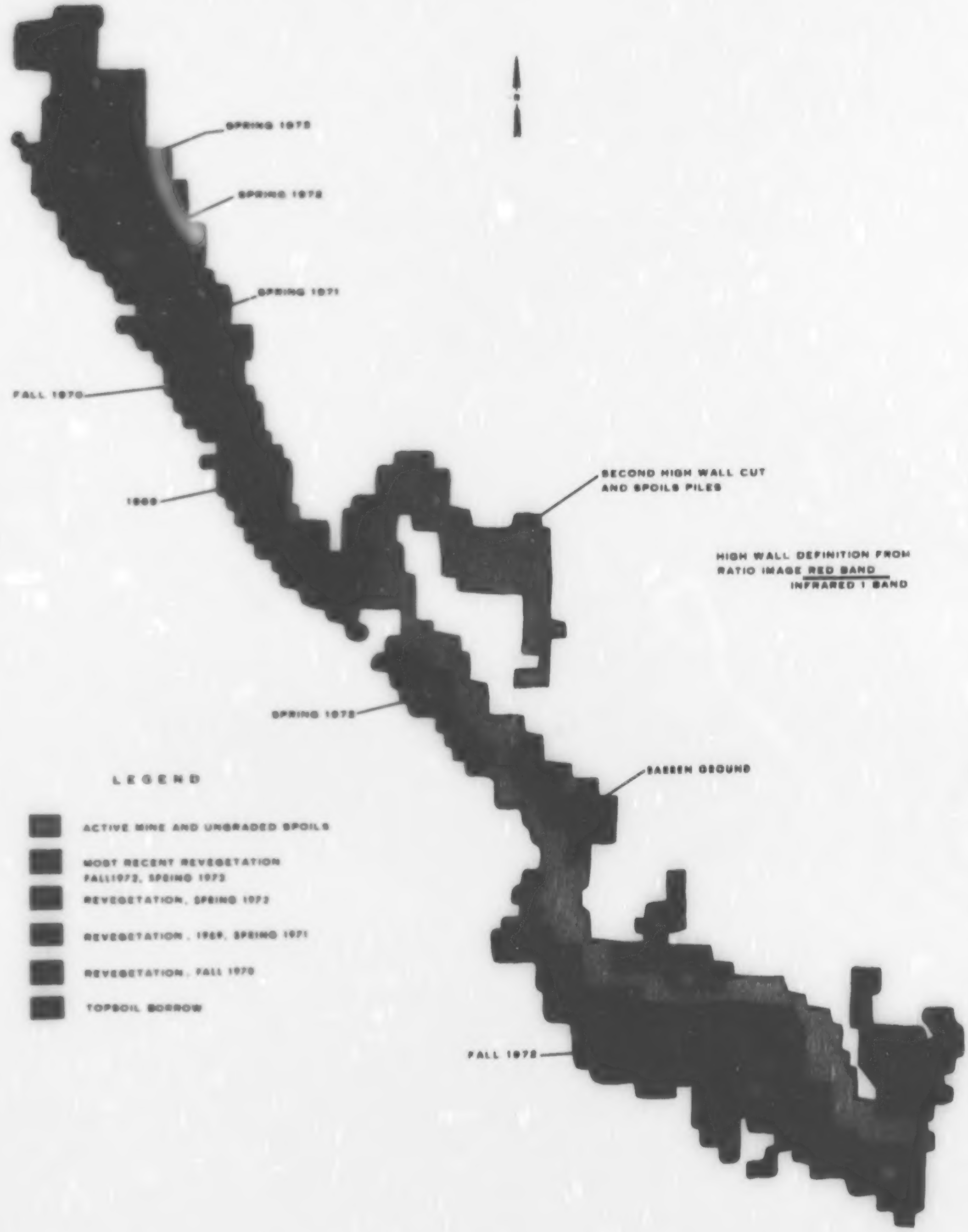

SPRING 1973
SPRING 1972
SPRING 1971
FALL 1970
1969
SECOND HIGH WALL CUT
AND SPOILS PILES
HIGH WALL DEFINITION FROM
RATIO IMAGE RED BAND / INFRARED 1 BAND
SPRING 1972
BARREN GROUND
FALL 1972
LEGEND
ACTIVE MINE AND UNGRADED SPOILS
MOST RECENT REVEGETATION FALL1972, SPRING 1973
REVEGETATION, SPRING 1972
REVEGETATION, 1969, SPRING 1971
REVEGETATION, FALL 1970
TOPSOIL BORROW

FIGURE 3. CLASSIFICATION MAP OF DAVE JOHNSTON MINE
GLENROCK, WYOMING
PACIFIC POWER AND LIGHT COMPANY

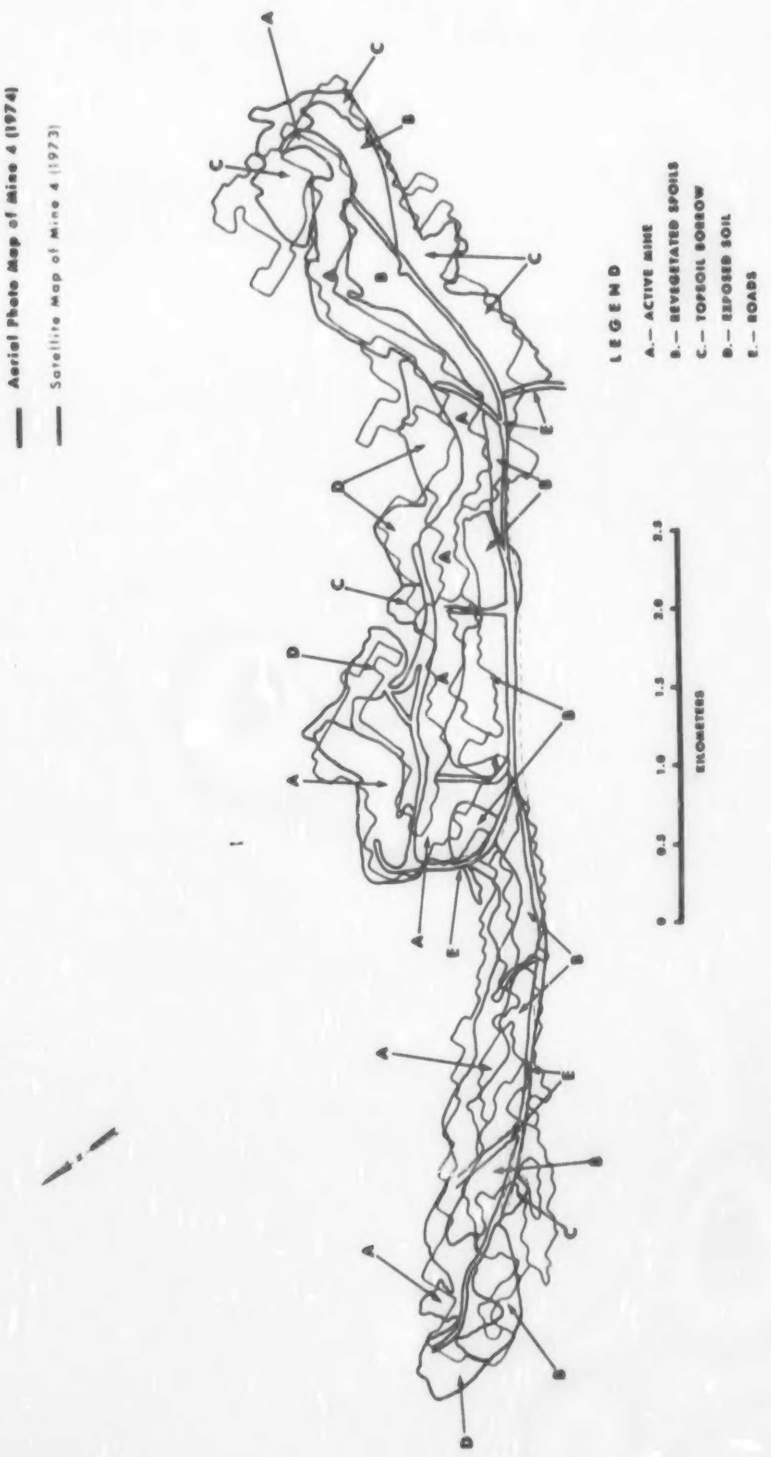

Aerial Photo Map of Mine 4 (1974)
Satellite Map of Mine 4 (1973)
LEGEND
A.— ACTIVE MINE
B.— REVEGETATED SPOILS
C.— TOPSOIL BORROW
D.— EXPOSED SOIL
E.— ROADS
0
0.5
1.0
1.5
2.0
2.5
KILOMETERS
A
B
C
D
E

FIGURE 4. A COMPARISON OF DAVE JOHNSTON CLASSIFICATION MAPS

In the northwestern corner of the mine, land revegetated in Spring 1973 was discernible from grass in an adjacent area planted one year earlier. A topsoil borrow area on the west side was also identified. Proceeding to the southeast, revegetated areas planted in 1969, 1970, and 1971 as designated on the map produced spectral signatures the same as undisturbed native vegetation thus indicating that a comparable density of vegetation had been achieved.

The southeastern portion of the mine contains much revegetated land and many topsoil borrow areas. In the borrow areas, a scraper has removed strips of topsoil leaving native vegetation in alternate strips. Some natural revegetation has taken place in the disturbed strips. The revegetated land and the borrow areas were spectrally indistinguishable from one another as both consist of areas of vegetation mingled with bare soil.

The land north of the highwall in the southeastern part of the mine had a signature characteristic of revegetation or topsoil borrow. No activity in this area was indicated in Figure 1. Lower altitude aerial photography verified that this was a topsoil borrow area.

By counting pixels, the computer keeps track of the area in each classification. The area of each classification for the Dave Johnston Mine is presented in Table 3. Of the 554 hectares (1,365 acres) of disturbed area, about 55 percent has been revegetated, a figure which agrees with the information given on Figure 1.

This technique has been applied to eastern areas on which surface clay mining has been practiced and vegetation has encroached back into the disturbed areas.*

---

*Garofalo, Donald and Frank J. Wobber, 1973, "Remote Sensing For Environmental Studies in Mined Areas", pp 32-48, in _Photographic Applications in Science, Technology, and Medicine_, Sept. 1973.

CHAPTER 7

ACKNOWLEDGEMENTS

We are indebted to Mr. Gary Glass, Staff Coal Geologist of the Wyoming Geological Survey for his assistance, guidance and interest in preparing this report. We are similarly indebted to Dr. A. William Johnson of North Dakota's Regional Environmental Assessment Program (REAP) and to Mr. John Smith of the North Dakota Lignite Council, for their efforts in tracking pertinent data for North Dakota operations. We wish to thank Mr. Doss White, Bureau of Mines, Department of Interior, for his invaluable assistance and Mr. C. C. McCall, Director of Reclamation, Montana Department of Lands, for his staff's reviews.

We are also pleased to have this opportunity to publicly acknowledge the assistance afforded us over the past four years by coal mine operators who have graciously allowed us to view the details of their mining operations and have been most responsive in answering our questions.

Messrs. Ed Arthur and Al Pressman of EPA's Remote Sensing Laboratory in Las Vegas, Nevada, are to be commended for their assistance in acquiring and processing all of the photography and for their advice in preparing the report.

The report is published with the support of Region VIII and the Office of Energy, Minerals and Industry, Office of Research and Development, of the Environmental Protection Agency.

Mr. Edward Mangold and Mr. Arthur Dybdahl of the EPA organized and conducted the evaluation of mined lands using satellite imagery and thus provided the information used to prepare Chapter 5.

The author retains responsibility for any errors contained in this report and apologizes, in advance, for them.

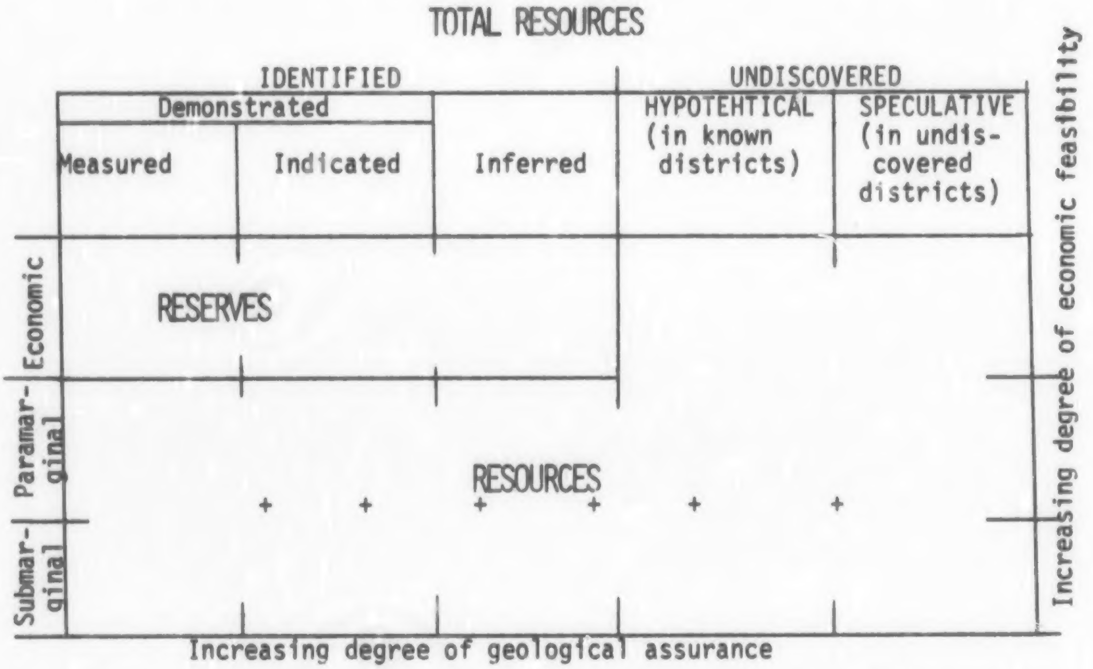
APPENDIX I

MINERAL RESOURCE TERMINOLOGY ADOPTED BY INTERIOR DEPARTMENT

DEFINITIONS:

Resource - A concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Identified Resources - Specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category.


TOTAL RESOURCES
IDENTIFIED
UNDISCOVERED
Demonstrated
Measured
Indicated
Inferred
HYPOTEHTICAL (in known districts)
SPECULATIVE (in undis- covered districts)
Economic
Paramar- ginal
Submar- ginal
RESERVES
RESOURCES
Increasing degree of geological assurance
Increasing degree of economic feasibility

Undiscovered Resources - Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory.

Reserve - That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term ore is also used for reserves of some minerals.

APPENDIX I
(cont'd)

The following definitions for measured, indicated, and inferred are applicable to both the Reserve and Identified-Subeconomic resource components (see chart).

Measured - Material for which estimates of the quality and quantity have been computed, within a margin of error of less than 20 percent, from analyses and measurements from closely spaced and geologically well-known sample sites.

Indicated - Material for which estimates of the quality and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections.

Demonstrated - A collective term for the sum of materials in both measured and indicated resources.

Inferred - Material in unexplored but identified deposits for which estimates of the quality and size are based on geologic evidence and projection.

Identified-Subeconomic Resources - Known deposits not now minable economically.

Paramarginal - The portion of subeconomic resources that (a) borders on being economically producible or (b) is not commercially available solely because of legal or political circumstances.

Submarginal - The portion of subeconomic resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) or a major cost-reducing advance in technology.

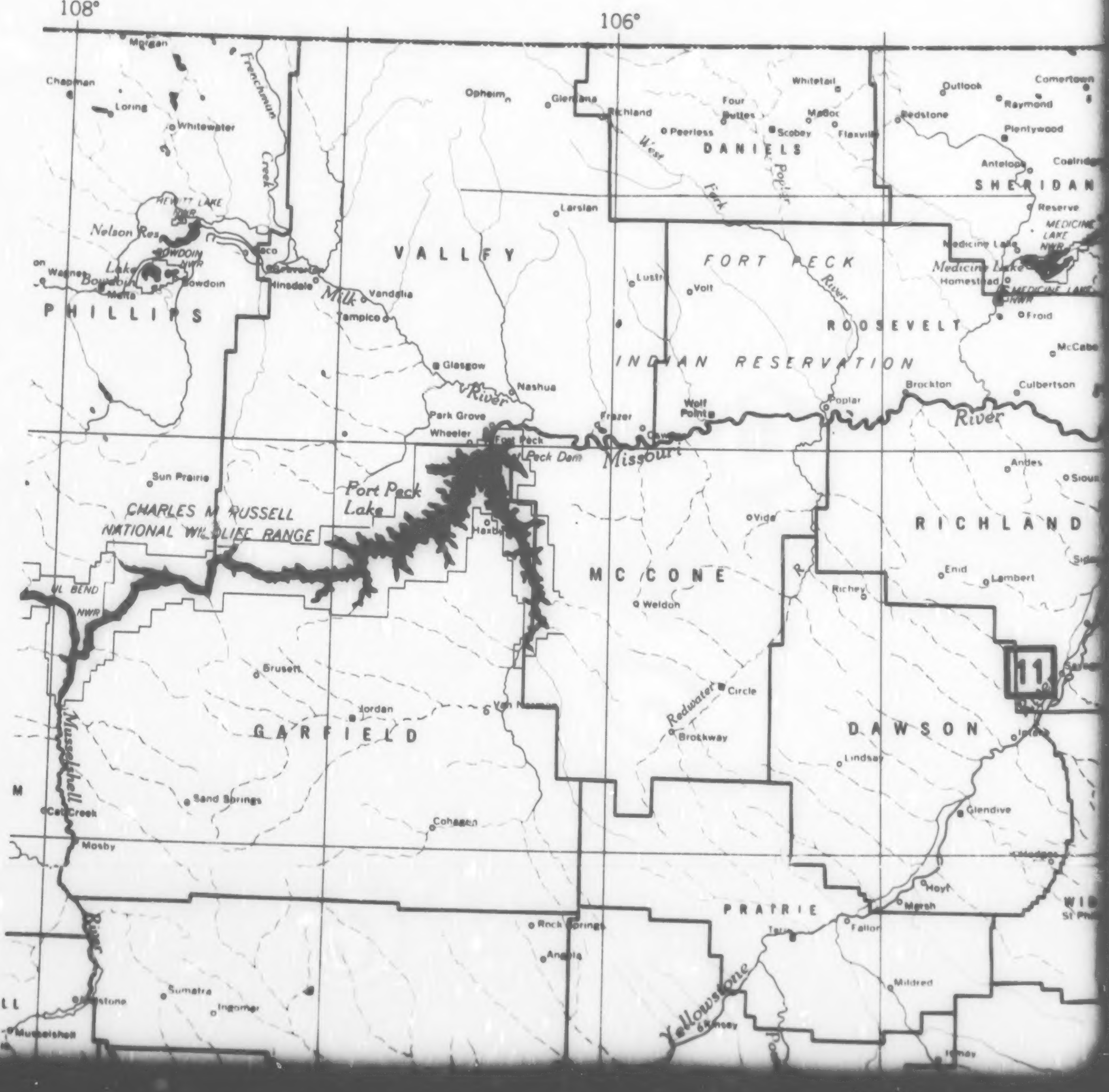
Hypothetical Resources - Undiscovered materials that may reasonably be expected to exist in a known mining district under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as a Reserve or identified-subeconomic resource.

Speculative Resources - Undiscovered materials that may occur either in known types of deposits in a favorable geologic setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as reserves of identified-subeconomic resources.

LOCATION OF OPER

IN THE NORTH

19



108°
106°
Morgan
Chapman
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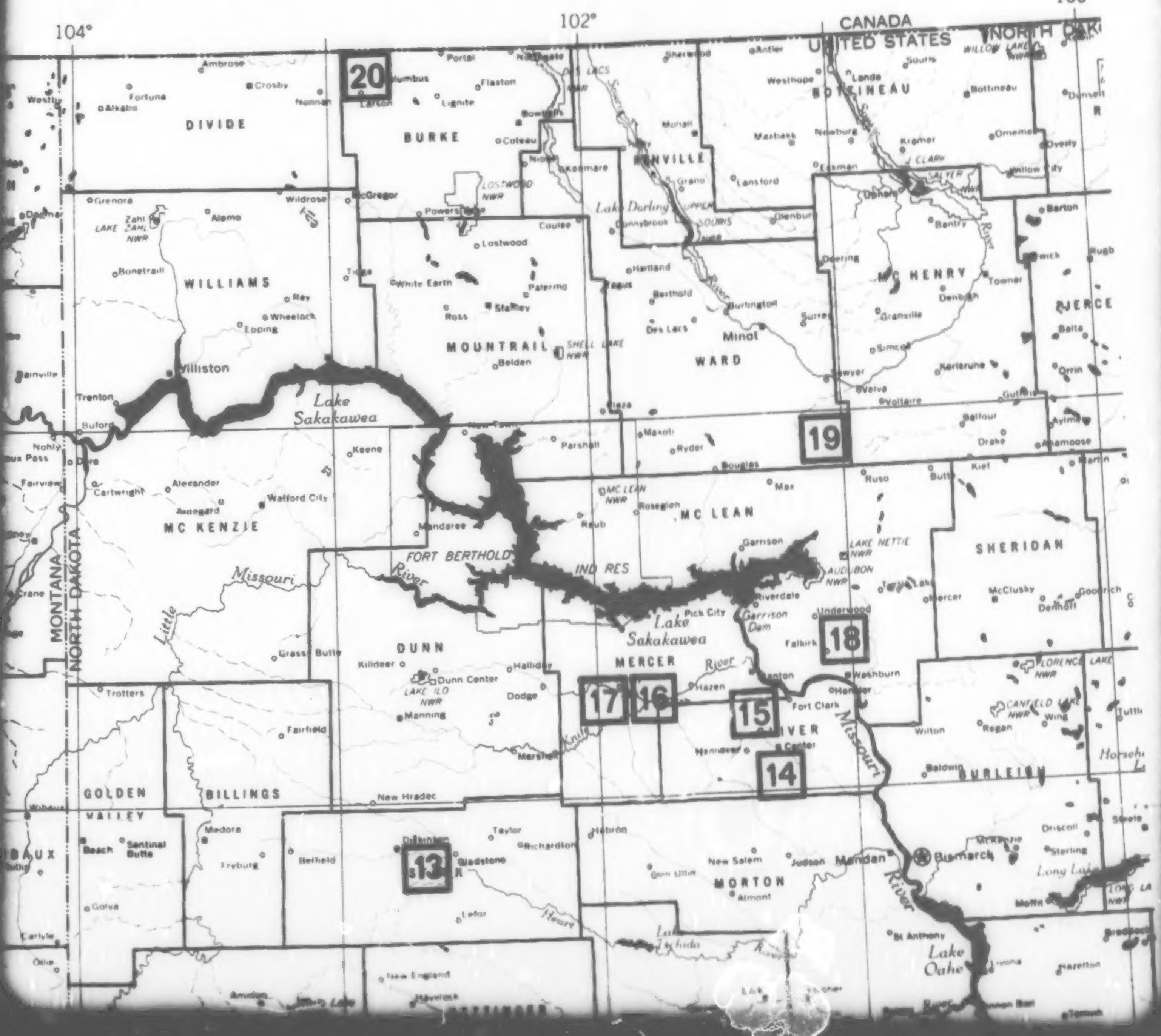
Whitewater
Frenchman Creek
HEWITT LAKE NWR
Nelson Res
BOWDOIN NWR
Lake Bowdoin
Bowdoin
Wagner
Malta
Saco
Hinsdale
PHILLIPS
VALLEY
Milk
Vandalia
Tampico
Glasgow
River
Nashua
Park Grove
Wheeler
Fort Peck
Fort Peck Dam
Opheim
Glentana
Richland
Peerless
DANIELS
Four Buttes
Whitetail
Scobey
Flaxville
West Fork
Poplar
Larslan
FORT PECK
INDIAN RESERVATION
Lustre
Volt
River
ROOSEVELT
Frazer
Wolf Point
Poplar
Brockton
Culbertson
Missouri
River
Outlook
Comertown
Raymond
Redstone
Plentywood
Antelope
Coalridge
SHERIDAN
Reserve
MEDICINE LAKE NWR
Medicine Lake
Homestead
Froid
McCabe
Sun Prairie
Port Peck Lake
CHARLES M RUSSELL
NATIONAL WILDLIFE RANGE
UL BEND NWR
Andes
RICHLAND
Vida
MC CONE
Weldon
Richey
Enid
Lambert
11
Brusett
Jordan
Van Norman
GARFIELD
Circle
Redwater
Brockway
DAWSON
Lindsay
Musselshell
M
Sand Springs
Cat Creek
Mosby
Cohagen
Glendive
Hoyt
Marsh
PRAIRIE
Terry
Fallon
Rock Springs
Angela
River
Sumatra
Ingomar
Mildred
Yellowstone
Kinsey
Ismay
LL
Musselshell
St Phil

RATING SURFACE MINES
ERN GREAT PLAINS
974-75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102°
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RENVILLE
BOTTINEAU
WILLIAMS
MOUNTRAIL
WARD
MC HENRY
PIERCE
MC KENZIE
MC LEAN
SHERIDAN
DUNN
MERCER
OLIVER
GOLDEN VALLEY
BILLINGS
MORTON
BURLEIGH
MONTANA
NORTH DAKOTA
Lake Sakakawea
FORT BERTHOLD IND RES
Missouri River
Little Missouri
Knife River
Heart River
Lake Oahe
Lake Darling
Williston
Minot
Bismarck
Mandan
Dickinson
Garrison Dam
Pick City
Washburn
Hazen
Beulah
Center
Gladstone
Underwood
Crosby
Columbus
Larson
Portal
Noonan
Kenmare
Bowbells
Fortune
Ambrose
Alkabo
Grenora
Zahl
Alamo
Wildrose
McGregor
Tioga
Ray
Wheelock
Epping
Stanley
Ross
White Earth
Palermo
Belden
Parshall
New Town
Keene
Alexander
Cartwright
Watford City
Arnegard
Mandaree
Grassy Butte
Killdeer
Dunn Center
Halliday
Dodge
Manning
Trotters
Fairfield
Medora
Belfield
Taylor
Richardton
New Salem
Glen Ullin
Judson
Almont
Hebron
New Hradec
New England
Lefor
Beach
Sentinel Butte
Golva
Carlyle
Trenton
Buford
Fairview
Sherwood
Mohall
Glenburn
Burlington
Berthold
Des Lacs
Kenmare
Towner
Velva
Sawyer
Max
Ruso
Butte
Garrison
Riverdale
Turtle Lake
Mercer
McClusky
Denhoff
Goodrich
Falkirk
Hensler
Fort Clark
Stanton
Hannover
Wilton
Regan
Wing
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Sterling
McKenzie
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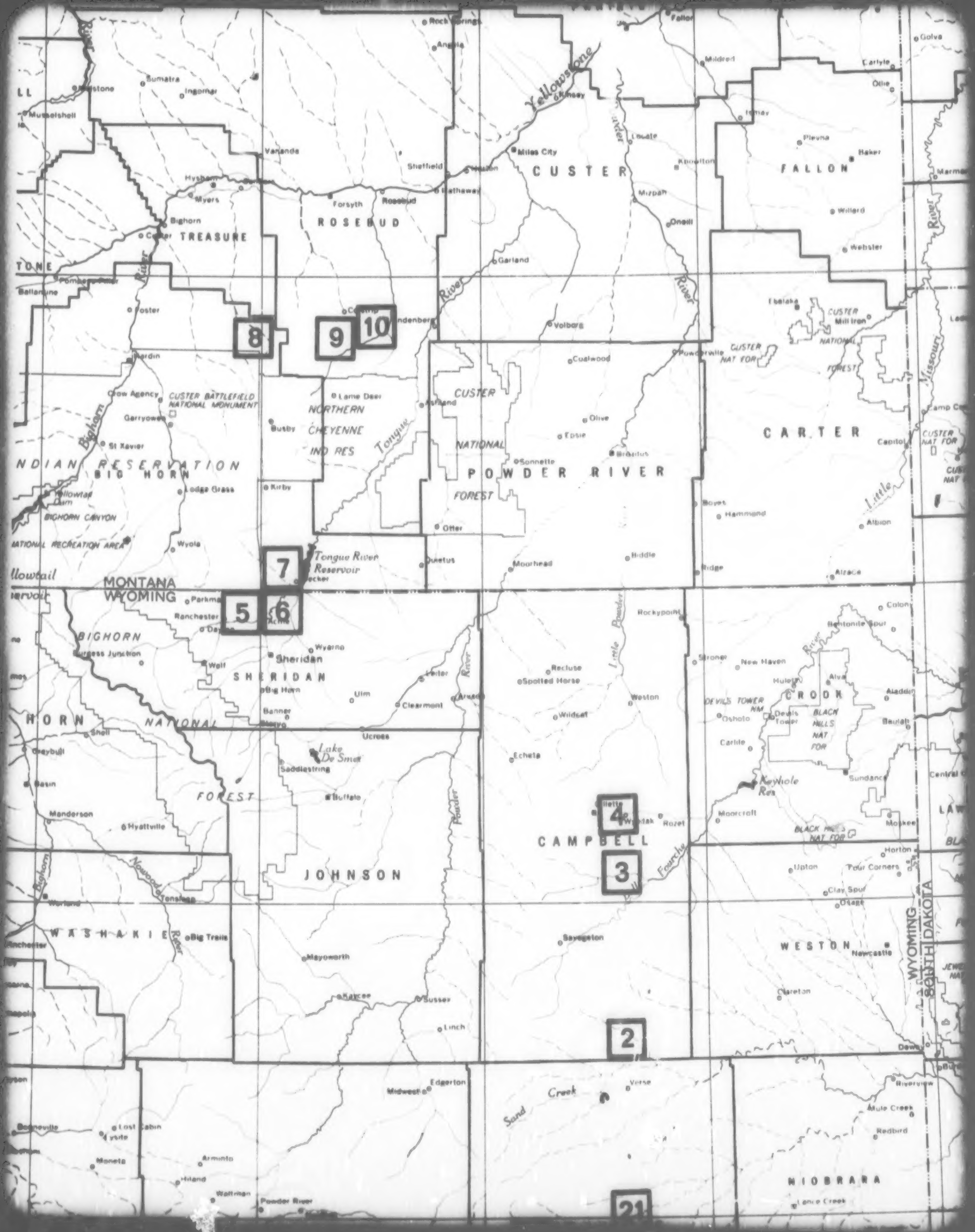
Moffit
St Anthony
Hazelton
LOSTWOOD NWR
SHELL LAKE NWR
LAKE ZAHL NWR
LAKE ILO NWR
AUDUBON NWR
LAKE NETTIE NWR
UPPER SOURIS NWR
J CLARK SALYER NWR
CANFIELD LAKE NWR
FLORENCE LAKE NWR
LONG LAKE NWR



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MONTANA
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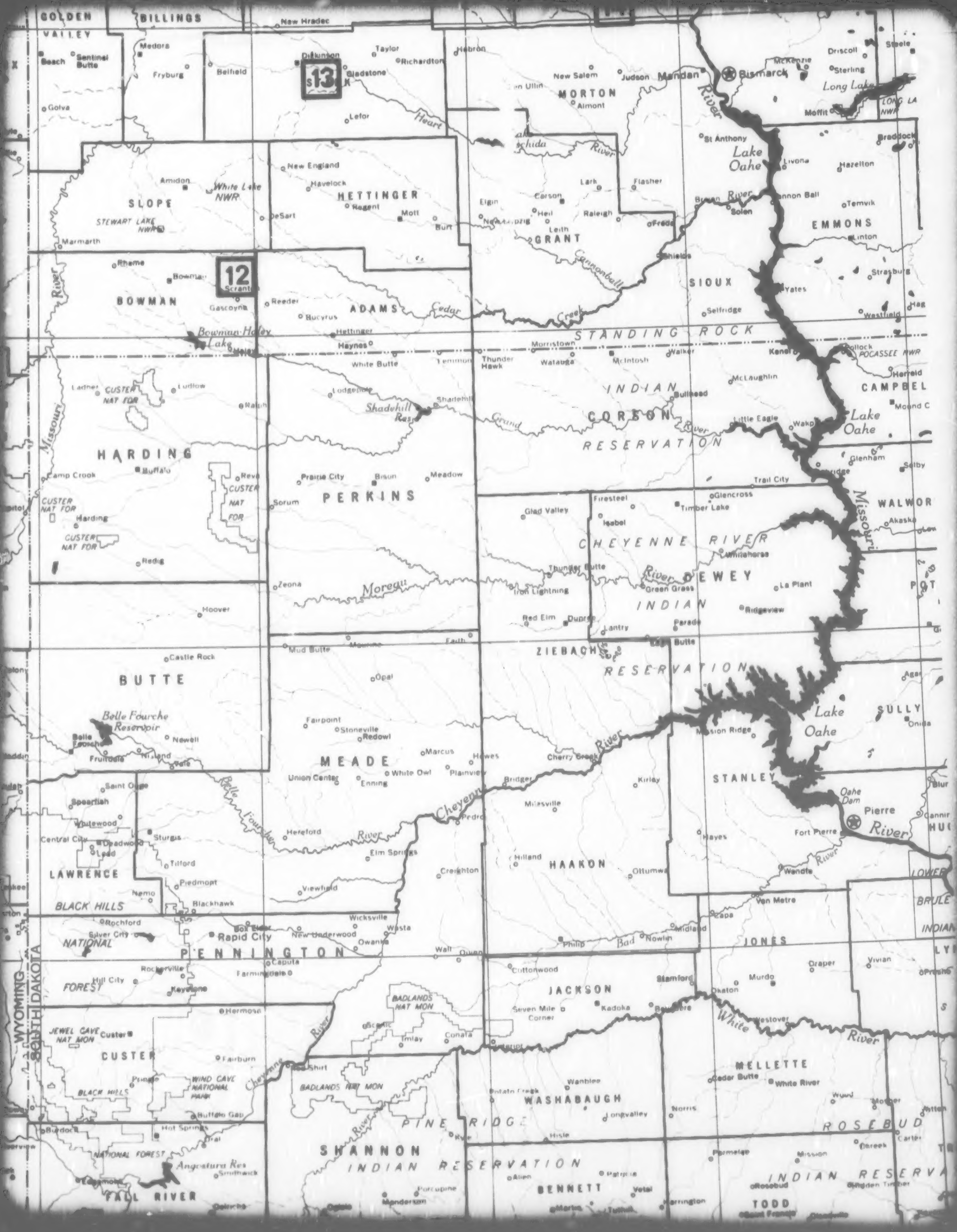
WYOMING
SOUTH DAKOTA
ROSEBUD
TREASURE
CUSTER
FALLON
CARTER
POWDER RIVER
BIG HORN
NORTHERN CHEYENNE IND RES
SHERIDAN
JOHNSON
CAMPBELL
CROOK
WESTON
WASHAKIE
NIOBRARA
Yellowstone
Tongue River Reservoir
Tongue
Powder River
Little Powder
Bighorn
Little Missouri
Belle Fourche
Nowood River
Sand Creek
CUSTER BATTLEFIELD NATIONAL MONUMENT
BIGHORN CANYON NATIONAL RECREATION AREA
Yellowtail Dam
CUSTER NATIONAL FOREST
CUSTER NAT FOR
BIGHORN NATIONAL FOREST
BLACK HILLS NAT FOR
DEVILS TOWER NM
Keyhole Res
Lake De Smet
Miles City
Forsyth
Rosebud
Colstrip
Lame Deer
Ashland
Busby
Kirby
Decker
Hardin
Crow Agency
Garryowen
St Xavier
Lodge Grass
Wyola
Sheridan
Ranchester
Dayton
Parkman
Acme
Wyarno
Big Horn
Buffalo
Gillette
Wyodak
Rozet
Weston
Recluse
Spotted Horse
Wildcat
Echeta
Savageton
Verse
Broadus
Sonnette
Otter
Quietus
Moorhead
Biddle
Olive
Epsie
Volborg
Garland
Powderville
Coalwood
Ekalaka
Mill Iron
Camp Crook
Capitol
Albion
Alzada
Ridge
Boyes
Hammond
Baker
Plevna
Ismay
Mildred
Fallon
Carlyle
Ollie
Willard
Webster
Locate
Knowlton
Mizpah
Oneill
Ingomar
Sumatra
Vananda
Sheffield
Hysham
Myers
Bighorn
Custer
Pompeys Pillar
Ballantine
Foster
Angela
Rock Springs
Colony
Bentonite Spur
Aladdin
Beulah
Hulett
Alva
Sundance
Devils Tower
Oshoto
Carlile
Moorcroft
Stoner
New Haven
Upton
Four Corners
Clay Spur
Osage
Newcastle
Clareton
Horton
Moskee
Dewey
Riverview
Mule Creek
Redbird
Lance Creek
Edgerton
Midwest
Kaycee
Sussex
Linch
Mayoworth
Ucross
Clearmont
Leiter
Arvada
Ulm
Banner
Story
Saddlestring
Shell
Greybull
Basin
Manderson
Hyattville
Tensleep
Worland
Big Trails
Burgess Junction
Wolf
Lost Cabin
Lysite
Moneta
Arminto
Hiland
Waltman
Powder River
Musselshell
Melstone
Golva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New Salem
MORTON
Almont
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Mandan
Bismarck
River
McKenzie
Driscoll
Sterling
Long Lake
Steele
Moffit
LONG LAKE NWR
St Anthony
Lake Oahe
Livona
Hazelton
Braddock
Schida
River
SLOPE
Amidon
White Lake NWR
STEWART LAKE NWR
Marmarth
DeSart
New England
Havelock
HETTINGER
Regent
Mott
Burt
Elgin
New Leipzig
Carson
Heil
Leith
GRANT
Lark
Raleigh
Flasher
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Cannon Ball
Temvik
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Solen
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Bucyrus
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ADAMS
Cedar
Creek
Hettinger
Haynes
Bowman-Haley Lake
STANDING ROCK
Pollock
POCASSEE NWR
Herreid
Morristown
Watauga
McIntosh
Walker
Kenel
Thunder Hawk
Lemmon
White Butte
Lodgepole
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Ralph
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Buffalo
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Reva
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Bullhead
McLaughlin
CORSON
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River
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CAMPBELL
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Glenham
Mobridge
Selby
Prairie City
Bison
Meadow
PERKINS
Sorum
Trail City
Glencross
Firesteel
Timber Lake
Isabel
Glad Valley
Missouri
WALWORTH
Akaska
CHEYENNE RIVER
Whitehorse
Thunder Butte
River
Green Grass
DEWEY
La Plant
INDIAN
Ridgeview
Parade
Lantry
Eagle Butte
Zeona
Moreau
Iron Lightning
Red Elm
Dupree
Hoover
Mud Butte
Maurine
Faith
ZIEBACH
RESERVATION
Castle Rock
BUTTE
Opal
Belle Fourche Reservoir
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Newell
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Redowl
MEADE
Marcus
Howes
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Hilland
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Creighton
Ottumwa
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Nemo
Blackhawk
Viewfield
Wendte
Van Metre
LOWER BRULE
INDIAN
Rochford
Silver City
NATIONAL
Rapid City
Box Elder
New Underwood
Wicksville
Wasta
Owanka
Capa
Midland
Nowlin
Bad
Philip
JONES
Wall
Quinn
PENNINGTON
Caputa
Farmingdale
Cottonwood
Hill City
Rockerville
Keystone
FOREST
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Stamford
Draper
Murdo
Okaton
Vivian
Presho
Seven Mile Corner
Kadoka
Belvidere
White
Westover
River
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Scenic
Interior
Conata
Imlay
JEWEL CAVE NAT MON
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Fairburn
WIND CAVE NATIONAL PARK
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Buffalo Gap
Cheyenne
Red Shirt
BADLANDS NAT MON
MELLETTE
Cedar Butte
White River
Wood
Mosher
Potato Creek
Wanblee
WASHABAUGH
Longvalley
Norris
WYOMING
SOUTH DAKOTA
Burdock
Hot Springs
Oral
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Angostura Res
Smithwick
Edgemont
FALL RIVER
Oelrichs
PINE RIDGE
Rockyford
Hisle
SHANNON
INDIAN RESERVATION
Parmelee
Mission
Okreek
ROSEBUD
Carter
INDIAN RESERVATION
Allen
Patricia
BENNETT
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Harrington
Rosebud
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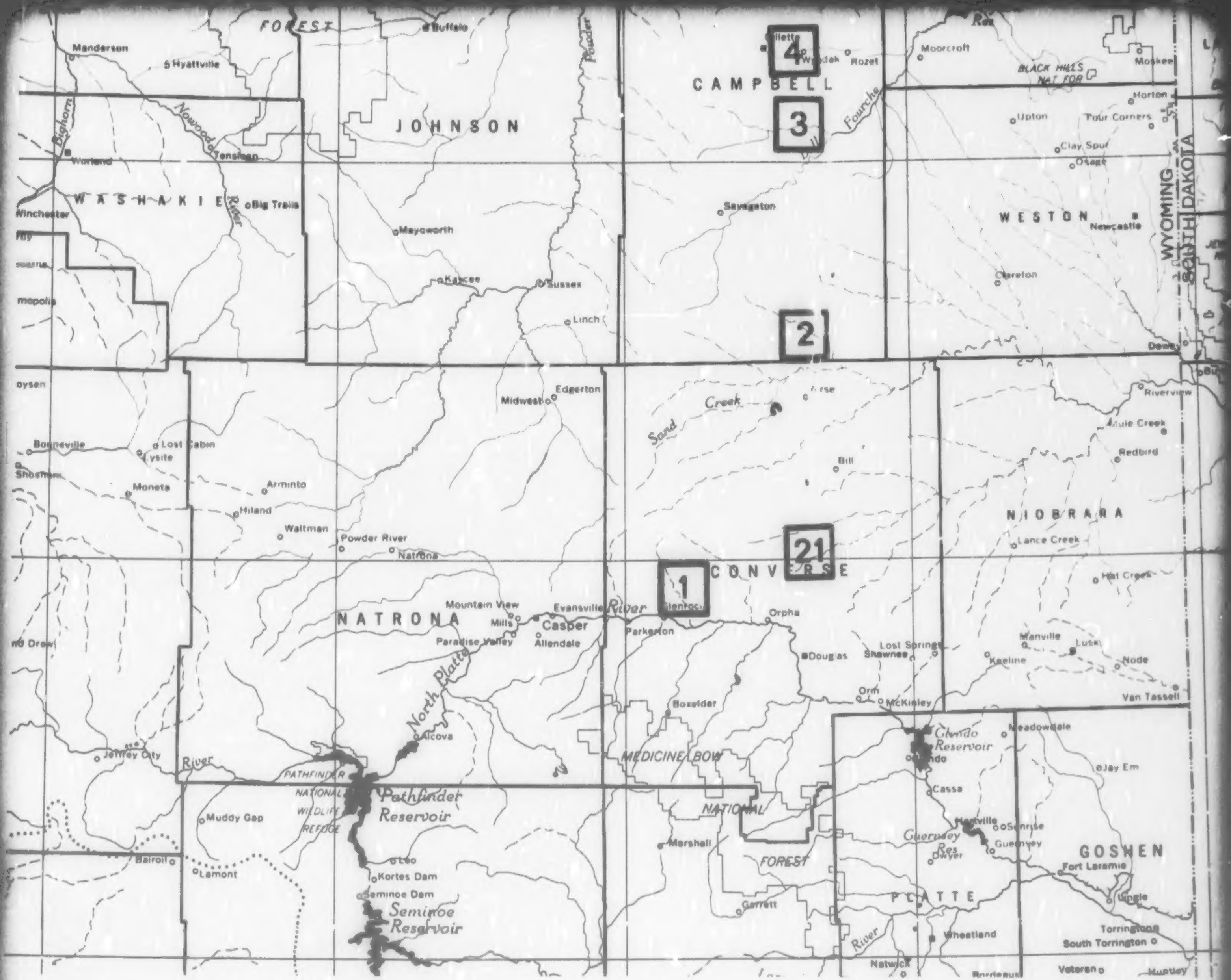
Witten
Gunsdrum Timber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MEDICINE BOW NATIONAL FOREST
PATHFINDER NATIONAL WILDLIFE REFUGE
Pathfinder Reservoir
Seminoe Reservoir
Glendo Reservoir
Guernsey Res
North Platte
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Powder
Nowood River
Bighorn
Buffalo
Manderson
Hyattville
Worland
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Big Trails
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Rozet
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Moskee
Horton
Upton
Four Corners
Clay Spur
Osage
Savageton
Newcastle
Clareton
Dewey
Edgerton
Midwest
Riverview
Mule Creek
Redbird
Bill
Lance Creek
Hat Creek
Arminto
Hiland
Waltman
Powder River
Natrona
Lost Cabin
Lysite
Moneta
Bonneville
Shoshoni
Mountain View
Mills
Evansville
Casper
Paradise Valley
Allendale
Glenrock
Parkerton
Orpha
Douglas
Lost Springs
Shawnee
Manville
Lusk
Keeline
Node
Van Tassell
Orin
McKinley
Boxelder
Meadowdale
Jay Em
Glendo
Cassa
Hartville
Sunrise
Guernsey
Dwyer
Fort Laramie
Lingle
Torrington
South Torrington
Veteran
Huntley
Wheatland
Natwick
Bordeaux
Marshall
Garrett
Alcova
Jeffrey City
Muddy Gap
Bairoil
Lamont
Leo
Kortes Dam
Seminoe Dam
Winchester
Thermopolis
Boysen

KEY TO MINES

1 Dave Johnston Mine

2 East Antelope Mine

3 Belle Ayr South Mine

4 Wyodak Mine

5 Welch Strip Mine

6 Big Horn Mine

8 Sarpy Creek (Absaloka) Mine

9 Big Sky Mine

10 Rosebud Mine

11 Savage Mine

12 Peerless Mine

13 Lehigh (Husky) Mine

14 Canter Mine

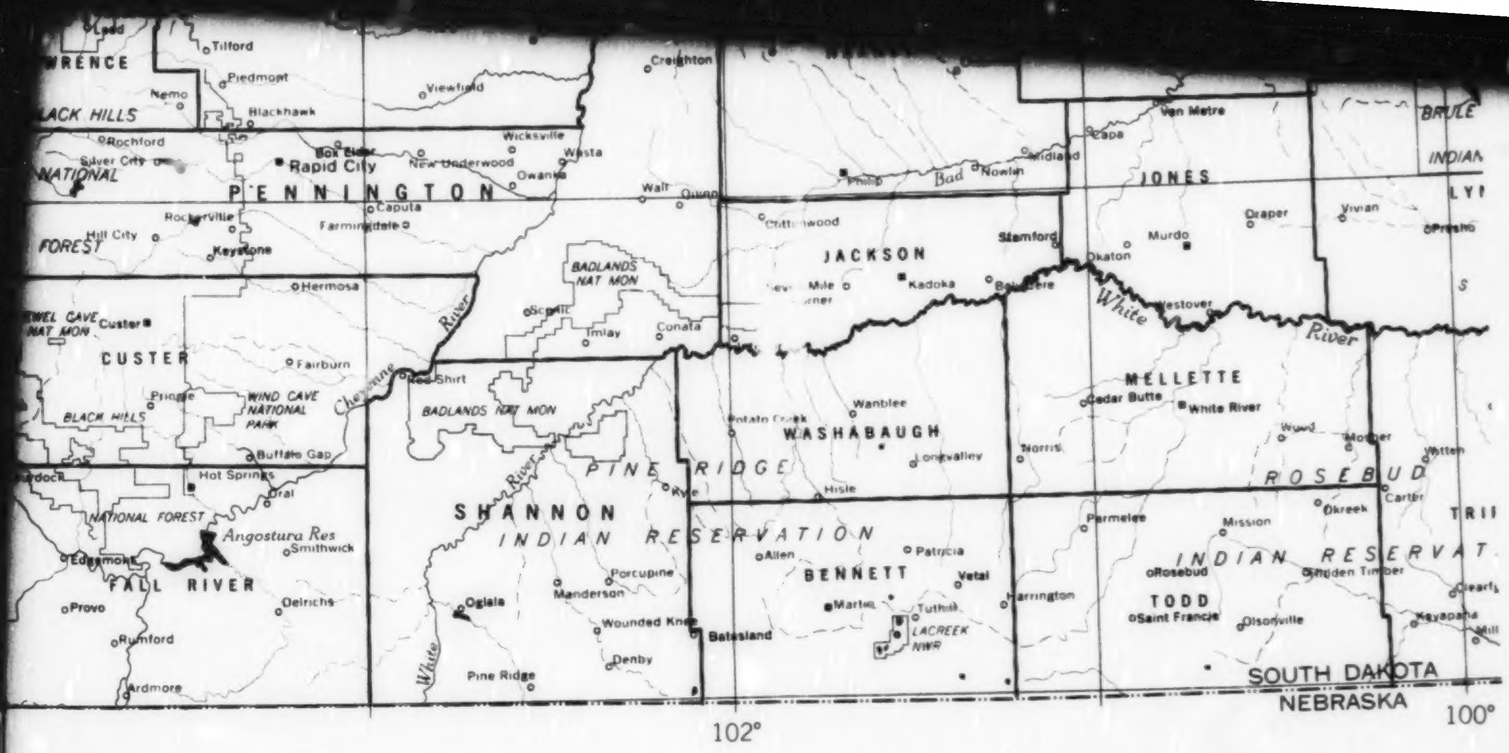
LAWRENCE
BLACK HILLS
NATIONAL
FOREST
PENNINGTON
Rapid City
JACKSON
JONES
BRULE
INDIAN
BADLANDS NAT MON
CUSTER
WIND CAVE NATIONAL PARK
JEWEL CAVE NAT MON
Cheyenne River
White River
MELLETTE
WASHABAUGH
SHANNON
PINE RIDGE INDIAN RESERVATION
ROSEBUD INDIAN RESERVATION
BENNETT
TODD
FALL RIVER
Angostura Res
LACREEK NWR
SOUTH DAKOTA
NEBRASKA
102°
100°
42°

PLATE 1

0 50 100

MILES

15	Glenharold Mine
16	Beulah (North and South) Mine
17	Indian Head Mine
18	Underwood Mine
19	Velva Mine
20	Noonan Mine
21	Highland Uranium Mill and Mine